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AUGUST, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

Grain Elevators, Cleaners, and Dryers. By ALFRED P. BOLLER, C. E.

Continued from page 11.

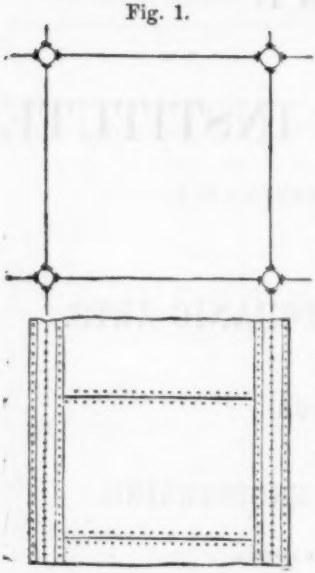
In the last paper a general description was given of permanent elevators and such arrangements in connexion with them as are at present in use for cleaning and drying grain. It now remains to notice briefly the construction and operation of floating elevators. Before doing so, however, it will be interesting to see what progress has been made in constructing bins of wrought iron, for it must be remembered that this department of construction is one that is peculiarly liable to destruction from fire.

We believe that the only permanent elevator constructed of fireproof material, both inside and out, is the one built by the Pennsylvania Railroad Company, at Philadelphia, some three years since. Its capacity is 450,000 bushels of grain, and receives from cars only, transferring to vessels for the European market direct. The shell of the building is brick, the bins themselves being high boiler-plate cylinders, twelve feet in diameter, resting upon parabolic cast iron girders supported upon cast iron columns ten inches in diameter. The roof is slated, the trusses for its support being of wrought iron. The warehouse is situated some distance from the slip, and the grain is carried to the vessel upon an endless canvas belt, protected by a long hollow box through which it passes. A considerable amount of storage room

must be lost from the cylindrical construction of the bins, although it is a very strong one.

The annexed Plate II., Fig. 8, shows an isometrical view of an arrangement for a fire-proof bin proposed by the writer, which, although never as yet practically tried, seems to promise, with simplicity of construction, economy of material and bin space. As in the elevator of the Pennsylvania Railroad Company, the bins are supported upon cast iron columns, but, unlike that elevator, the plan of the bin is rectangular. The bottoms of bins rest upon heavy rolled Phœnix beams, the sides are sheets of boiler-plate iron riveted together, and the intersections are wrought iron Phœnix cylinders rolled in four segments. Each segment has broad lips rolled with it, so that all four may be riveted together, and also to the plates forming the sides, as the sketch plainly illustrates. When the bins are high, the joinings of the plates forming the sides have T-iron riveted upon them the proper distance up in order to obtain lateral stiffness.

Fig. 1.



The annexed figures show a plan and portion of elevation of one of these bins, and how the boiler-plate sheets are introduced between the lips of the segments where they are secured by riveting. The hopper-shaped bottom is readily formed by using either cast or wrought iron cross girders made in the proper form, as represented in the isometrical sketch.

Floating Elevators.—Several attempts have been made to build floating elevators, but perhaps the most successful is the one described as Nimms & Clifford's patent. Two of these have been built, one for the Northern Railroad, to be used at Ogdensburg, and the other (the *Dictator*) for a private party in Buffalo. A detailed description of the latter will illustrate fully their method of working.

The *Dictator* is a propeller-built vessel, staunchly built, trenailed with locust and galvanized spikes. She is furnished with all modern improvements with that class of vessels, cabins and kitchen complete. The principal dimensions of this vessel are as follows:

Length over all	144 feet.	Width over all	26 feet.
Depth of hold	12 "	Between decks	8 "
Draft of water when loaded	13 "	Thickness of sides	22 ins.
Capacity for grain		16,600 bushels; equal to 500 tons.	
Maximum speed		13 miles per hour.	

She is supplied with a vertical engine having a 20 × 22 inch cylinder, the steam being supplied from two boilers. The power is transmitted to the elevating apparatus by means of the propeller-shaft,

which is made of forged iron in three sections. One section is connected with the propeller, one section, by means of the crank-arm, to the engine, and the other with the elevating machinery. Any two may be thrown in and out of gear by means of the ordinary clutch coupling. The annexed diagram, Fig. 2, shows the arrangement of the shafting, in which *a* and *b* are the clutch couplings and *c d* a vertical shaft receiving the power for the elevator.

Fig. 2.

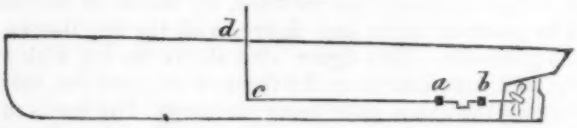


Plate II., Fig. 1, shows the transformation of motion from the horizontal shafting before spoken of to a vertical one operating the elevating machinery; A B is the prolonged shafting from the propeller-wheel; *c*, fly-wheel; *e*, beveled spur-gearing; G, cross-bearer for supporting shaft I; M, solid timbers forming foundation of turn-table bed. Fig. 2 shows plan and elevation of turn-table bed; X Y is the line of the upper deck; A A, &c., heavy oak posts springing from the timber foundations shown in Fig. 1; B, segments dove-tailed into posts A. The posts and segments are further secured by a system of knee-bracing strongly bolted to them, as shown in the drawing; *d d* friction-rollers upon which the turn-table rests. Fig. 3 shows the turn-table, formed of heavy oak segments in two layers, breaking-joint and the heavy frame-work upon which the machinery is supported; an end view and section through centre are also given. From what precedes, the turn-table will be readily recognised in Fig. 4, which shows, in connexion with the turn-table, the arrangement of the machinery which operates it, together with a portion of the upper frame-work and gearing, the receiving hopper, and weigh-scales room. The revolving of the table is effected by means of the hand-brake, A′, attached to the compound lever *a*; B′ B′ are friction-wheels of hard wood. The large wheel has a movable centre, supported on the lever O′, which lever is raised from the floor by a block of oak spiked to one of the foundation posts. To operate the turn-table, the man in attendance to the scales room turns the hand-brake, which presses the larger friction-wheel against the smaller one. The small wheel is attached to the shaft I, (which is the prolongation of I, Fig. 1,) and is constantly revolving. Thus the shaft of the larger friction-wheel receives motion, and, by means of a pinion on its upper extremity, works on the rack along the top edge of the turn-table, which rack is a semi-circumference of the whole table. Upon the same shaft with the smaller friction-wheel, and above it, is a spur-wheel, C′, operating upon its follower, D′, at the centre of the table, shown by their pitch circles merely in plan. Upon the centre shaft is a large spur-wheel, E′, with its follower, F′, which follower carries the shaft that operates the elevating machinery above the turn-table. Above the level of the top of the turn-table the elevation shows a portion of the frame-work

for supporting the shafting and gearing, and also the room appropriated to the weighing and receiving hoppers; $q\,q$ are quadrants of a spur-wheel attached to the shaft M N and operated by the pinions $b_1\,b_1$; W, windlass for coiling up the rope that raises the leg; H, spur-wheel which operates the pinions; R, receiving hopper; R′, weighing hopper; S, movable discharge spout.

In Fig. 5 the turn-table has revolved, by means of the hand-brake, 90° from its position in the last figure, with the leg thrown over the side of the propeller. This figure also shows the leg with its system of gearing and attachment to the frame-work, and the arrangement for discharging the grain after being elevated. The leg is made from boiler-plate iron riveted together, being connected at the corners by angle irons. It might be remarked, at this place, that the only iron leg ever as yet made is the one belonging to the *Dictator*, and it is one-third lighter than a wooden one, and immensely stronger. Square bars are secured to the sides, and slide in corresponding grooves in powerfully braced jaws swung at their centre on an axis, which is supported by a pair of strongly framed oak arms. The centre of movement of these arms lies immediately back of the posts, and is on, and firmly secured to, the shaft that carries the quadrants. (See Fig. 4.) These quadrants are operated by the spur gearing before described, and give a vertical motion to the arms, by means of which the jaws are raised, carrying the leg with them. Below the arms and quadrants is a grooved casting firmly secured to the posts, in which a rack slides, operated by a smaller pinion. (See *p*, Fig. 6.) At the outside end of the rack, a wrought iron fork is connected by a movable joint; this fork embraces the leg and regulates the amount of throw in a horizontal direction. At the foot of the leg is a set of sheaves, the ropes from which pass around another set at the end of the oak arms, and are wound up on the windlass before mentioned. In order that these ropes may be wound up regularly, they are directed by means of a pulley. (See *p*, in plan.) The mode of operating windlass will be shown further on. The belt carrying the buckets is driven by a head-pulley, the belting for which is shown in the figure passing over two sets of tension-pulleys, $n_1\,n_1$. In order to keep the axes of the tension-pulleys perfectly level, the journals are swelled at their ends, having corresponding cavities in the journal-boxes—a kind of ball and socket arrangement. A pair of set screws at each end, one above and one below, regulate the alignment of the axes. The tension-pulleys, sliding in grooves, have for rise and fall the distance o o′. At the foot of the elevator-leg are a pair of set screws, which are used either for tightening or for slackening the bucket-belt. The grain, when elevated, falls into a spout, K, the mouth of which slides in a vertical one, which directs the grain into a discharge-spout, *j*. This discharge-spout in turn directs the grain into the receiving hopper shown in the last figure. Immediately under the receiving hopper is the weighing hopper, from which the grain falls into a small hopper, U, just below the level of the top of the turn-table. The movable spout, S, either directs the grain through a port in the side of the propeller into a vessel adjoining, or into its

Floating Elevator
DICTATOR.

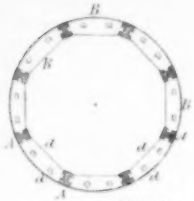


Fig. 2.

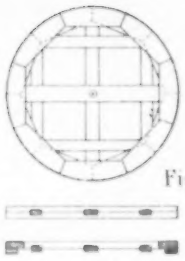
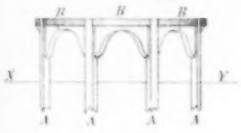


Fig. 3.



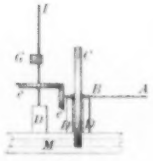


Fig. 1.

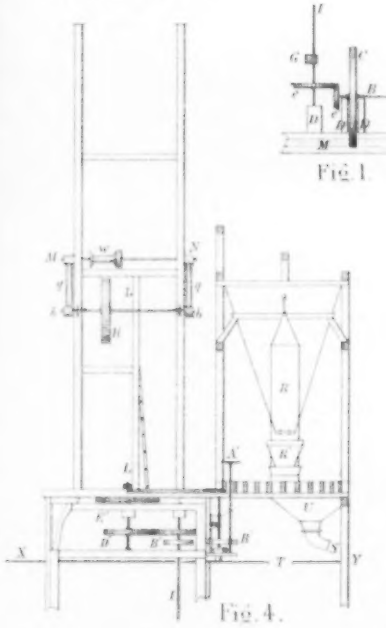


Fig. 4.

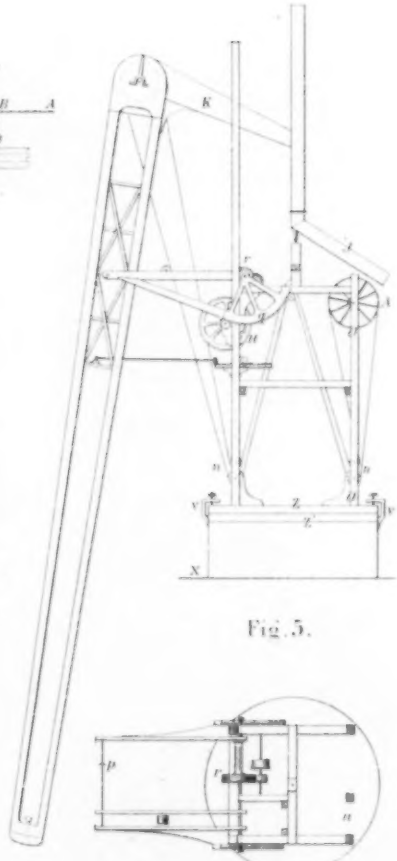


Fig. 5.

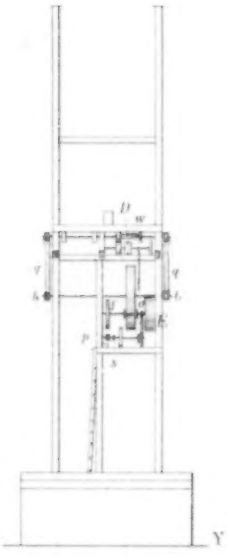


Fig. 6.

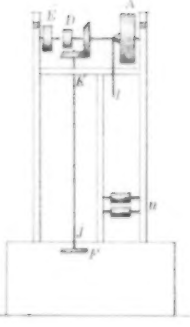
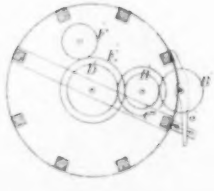
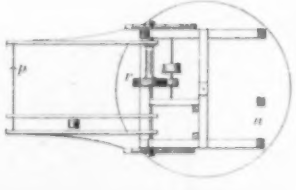


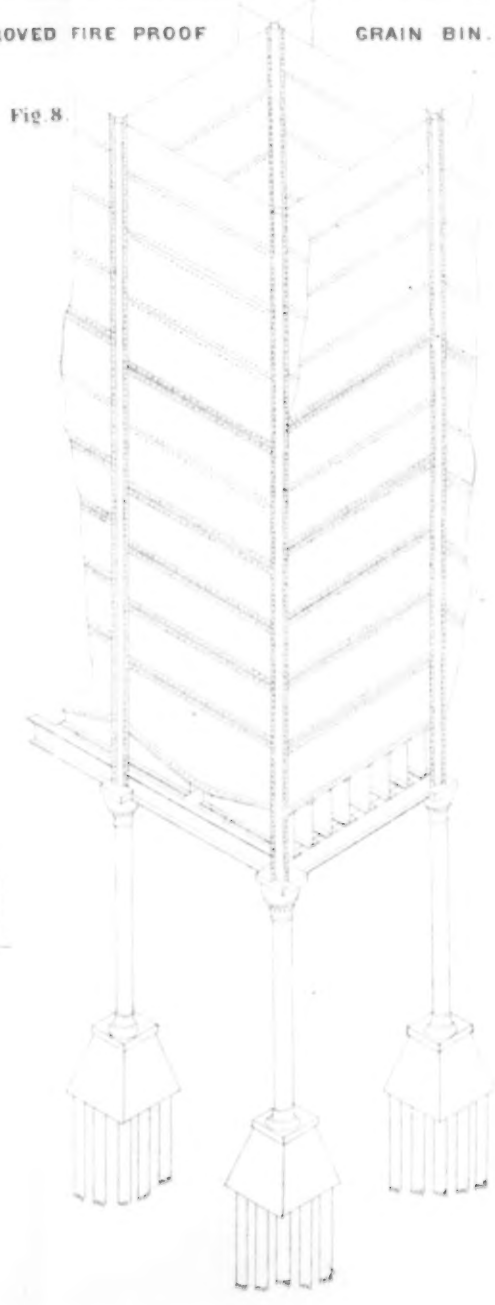
Fig. 7.





IMPROVED FIRE PROOF GRAIN BIN.

Fig. 8.



own hold by means of the receiving hatch T. Z is the turn-table; Z′, turn-table bed; v, v_1, iron dogs for clamping turn-table when in position; *r*, spur-wheel with drum operating windlass.

Fig. 6 shows the side elevation of the machinery to the left of the centre line in the last figure; *q q* are the quadrants; W, windlass; D, driving-pulley for hoisting apparatus, the belt running to D in Fig. 7. This driving-pulley is thrown in and out of gear by means of a clutch and lever. *b b* are the pinions working quadrant. On the pinion-shaft is a spur-wheel (*vide* Figs. 4 and 5) operated by a pinion on a shaft, having attached to it, by a clutch coupling, a pulley, E, which receives the band from E′ in Fig. 7, and is used to raise or lower the leg; S is a small ratchet for working by hand the rack which has the iron fork attached to it previously described; *f* is a friction strap and wheel for lowering quadrants. Fig. 7 presents the side elevation of the machinery to the right of the centre line in Fig. 5. F is the spur-wheel shown by pitch circle F′ in plan of Fig. 4, and receives all the power for the machinery above the top of the turn-table, which power it transmits by means of the vertical shaft J K. By means of beveled spur-gearing, the power is transferred to a horizontal shaft. A is the main driving-pulley for working bucket-belt of the leg, shown at A, Fig. 5; it is thrown in and out of gear by the lever *l*; D and E′ are driving-pulleys before described in connexion with Fig. 6; *n* are tension-pulleys, sliding up and down between guides, shown in plan of Fig. 5. Having traced in detail the various parts and mode of operating the machinery, let us group them together and follow the whole connectedly, and take a glance at the practical working of this elevator. The average amount of grain carried by lake vessels is 16,000 bushels; some few carrying 25,000, and one or two as much as 30,000 bushels. Suppose a vessel desires to unload a cargo of 10,000 bushels. For that purpose the propeller carrying the elevator comes alongside of her, and they are lashed securely together. The elevator-leg is raised, pushed out horizontally, and is lowered into her hold. The grain is then elevated and discharged by means of the spouts previously described, weighed, and either transferred to a canal-boat on the other side, or stored in her own hold. Should there be, in addition to the grain, rolling freight to be unloaded, it may be stored between decks. All rolling freight is raised by means of a shaft running the whole length of the propeller, attached to the under side of the upper deck. This shaft carries friction-rollers and windlasses at every hatchway. By this means flour in barrels, boxes, castings, &c., are handled very rapidly at the same time that the grain is being elevated. The propeller has a full load now, and moves off to her pier. She first discharges her rolling freight, which is done by the same machinery with which she receives it, and is then ready to discharge her grain; or both operations may be conducted at the same time. The grain is spouted into bins placed along the edge of the pier. The construction and arrangement of the bins is restricted to no particular plan, other than their being placed along the edge of the pier or dock. The plan of bins adopted by the inventor of this floating elevator is a simple framing, so as to make the bins 12 feet in all dimen-

sions, and to hold 1300 bushels of grain, which is equal to a weight of about 41 tons. The bottoms of the bins are raised high enough to allow freight cars to run under them, and also to give room to a small movable weighing hopper running above the cars. To store 200,000 bushels of grain would require 154 bins, stretching over a distance of about 1800 feet. There might be two rows of bins instead of one, reducing the lineal distance one-half. Two trains of cars could be loaded in a very short time, especially if time is not lost by weighing before loading. The height to which these bins may be carried is, of course, limited by the position of the discharge-spout of the elevator. All that it is necessary to bear in mind is, that the bins must be no higher than the angle of discharge for grain, the minimum for which being 22°.

A considerable amount of room could therefore be gained by using up the space required by the weighing hopper for bin space, and perform all the necessary weighing on platform scales after the cars are loaded. Before closing this brief sketch of permanent and floating elevators, it may be interesting to know their usual cost. A few figures in regard to cost were mentioned in the first paper, but they represented the price of material and labor before the present inflation of our currency. A modern built permanent elevator to store 250,000 bushels of grain, with a transfer capacity of 5000 bushels per hour, would, at the present time, cost about $125,000, and this is exclusive of engines and boilers, and, of course, of drying or cleaning arrangements. The engines and boilers would be worth about $20,000 additional; making a total cost of a permanent elevator at least $145,000 before a bushel of grain could be stored.

The *Dictator* floating elevator cost $80,000, made up as follows: Elevating machine, $15,000; propeller engine, wheel, and shafting, $10,000; two boilers, $10,000; hull, complete, $45,000. In considering the cost of a floating elevator, there ought properly be added the cost of bins, and these two items would approach pretty nearly to the cost of a permanent elevator.

An Enormous Bridge.

From the London Athenæum, November.

A contemporary gives the following striking details of an enormous bridge now being constructed for the London and North-western Railway Company across the Mersey, between Runcorn and Liverpool. It approaches the north-east bank of the river at Runcorn Ferry, which it crosses at Runcorn by an enormous bridge, consisting of three wrought iron trellis girder openings, 305 feet in width each, and 75 feet in height, on the under side of the girders, above the level of the river at high water, thus permitting any vessel of ordinary size to pass under it. On the Lancashire, as well as on the Cheshire side of the river, these girders are supported by huge abutments crowned with castellated turrets, rising nearly 40 feet above the railway level, whilst in the river the girders are supported by immense stone piers. Having passed the Mersey, the railway is carried through the town of Runcorn

by a viaduct of 32 arches, passing over the Duke of Bridgewater's canal, a short distance from the west side of Runcorn church. By this addition to the railway eight miles are saved in the distance between Liverpool and London.

On Incrustation of Marine Boilers. By Mr. P. Jensen.

From the London Mechanics' Magazine, May, 1866.

At a meeting of the Society of Engineers, held on May 7, Zerah Colburn, Esq., President, in the chair, the following paper was read: The question of keeping marine boilers free from deposit or incrustations has, for many years, been one of the most prominent before the profession—in fact, ever since the first steamer entered sea-water—and it is still well worthy of our closest attention. It presents itself to us principally in three distinct forms, viz: safety against explosions, economy of fuel, and durability of the boiler itself. Now, we all know that sea-water causes incrustation and corrosion when boiled in a close vessel like a steam boiler. It is not, however, intended to enter into the question of internal corrosion of marine boilers, though closely connected with the subject before us, for fear of extending the length of this paper; but we may, in passing, note the fact that internal corrosion, below the level of the water in a marine boiler, does take place to some extent, where the scale has been removed, but that otherwise this scale, so injurious when allowed to accumulate to any thickness, acts the part of a shield or protector to the plates of the boiler, against the action of certain salts contained in sea-water, of which the muriate of magnesia is by far the most destructive, though happily small in quantity. And here the author may be allowed to call the attention of the meeting to an excellent paper, "On the Wear and Tear of Boilers," read before the Society of Arts, April 26, 1865, by Mr. F. A. Paget,* who treats the subject of corrosion of boilers very fully. In the ordinary practice of sea-going steamers with common condensers, the feed-water is drawn from the hot-well of the condenser, and thence forced into the boiler at some point or points near the bottom, and at a temperature of about 110° Fahr. The evaporation of steam leaves all, or sensibly all, saline or other extraneous matters contained in the water behind in the boiler, and, unless some means were adopted against it, we should, of course, soon get the boiler choked with incrustation or deposit. The means proposed or adopted for this purpose are many and varied, as will be seen in the sequel; but this much is certain, that any considerable thickness of scale allowed to accumulate renders the plates impervious to heat to a great extent, as this scale is a bad conductor. The heat generated in the furnace, and heating the plate next to it, cannot readily enough penetrate as far as the water, which, if in constant circulation, continually exposes fresh particles to the action of heat. The consequence is the overheating of the plates, and this to such an extent that holes may be burnt nearly through, leaving a sheet of iron

* See *Jour. Frank. Institute*, vol. l., 1865, page 13.

the thickness of writing paper. That explosions do and must occur by thus weakening the plates, or by rents thus formed, is an established fact, and has, for many years, formed the subject of many investigations and different theories, among which that called the percussive, first started and since completed by Mr. Zerah Colburn, seems the most natural, and has now probably become more generally adopted than any other. But even only partial explosions, caused by rents or collapse of internal parts of the boiler, have proved dangerous by scalding those that happened to be near at the time. The conducting power of wrought iron decreases with the temperature, so that at 400° Fahr. it has little more than half that at 32° Fahr.; how it stands with still higher temperatures we do not know as yet. If from some reason or other, such as the coating of the plate with incrustation, which has sixteen times less conducting power than iron, the plate, with its covering of crust, should become heated to above 340° Fahr., then the water would exist on its surface in a speroidal state, and thus only slowly and by the forcible ejection of it by colder water enable the heat contained in the plate to diffuse itself into the water; thus the plate would get hotter and hotter, and at last burn or oxidize where next to the fire. It is thus that plates are burned nearly through on account of incrustation. Important as is the question of the safety of the marine boiler against explosions, it cannot be denied that the economy of fuel, as regards marine boilers, has at all times, being a mere question of pounds, shillings, and pence, commanded, it is believed, as much attention as the consideration of human lives: witness the numerous patents, amounting to about one hundred and fifty, that have been taken out in this country for the prevention of incrustations and consequent loss in evaporative duty in marine boilers. Now, this is not an occasion for speaking about the patent laws, or entering into the desirability of maintaining, altering, or abolishing the same; but as one argument in favor of maintaining them struck the author while preparing this paper, which has a direct bearing on this and most other engineering questions, it would be worth while to hear what the opponents of the patent laws have to say against it. The question is simply this: How and where should we find such a complete record of the progress of engineering, inventive, and progressive talent but for the record of the Patent Office? In spite of all the nonsense that is patented, no doubt in sober earnest, still we find a vast amount of information in the specifications of patents. Would those that speak against patent laws like to do without the patent specifications? To return to the subject. It has been said above, that the scale has sixteen times less conducting power than iron. In an inquiry on incrustation of marine boilers by a Frenchman, M. Cousté, (*Annales des Mines*, 1854,) a paper hardly noticed in this country till Mr. Robert Trefusis Mallet, in the *Practical Mechanics' Journal*, September, 1862,* gave an extract of it, the following is stated: That, with marine boilers, starting quite clean inside, a loss of 8 per cent. or 10 per cent. of the evaporative duty of the fuel takes place after the first few days' work,

* See *Jour. Frank. Institute*, vol. xlv., 1863, page 51.

(a fact every marine engineer is aware of.) At Bordeaux, he found 15 per cent., and at Havre, after some days' constant work, he observed 40 per cent. In general practice, he says, it has been estimated that 40 per cent. of the heat of the fuel is lost by internal incrustation or deposit.* He gives the following analysis of the incrustations of French ocean steamers:

Stations.	Sulphate of Lime.	Carbonate of Magnesia.	Free Magnesia.	Iron and Aluminum.	Water.
Hamburg, (deposit from the surface of boiler partly crystalized)	85·20	2·25	5·95	.....	6·5
Mediterranean tubular boiler, (amorphous)	84·94	2·34	7·66	·41	4·65
Mediterranean, (amorphous deposit)	80·90	3·19	10·35	6·50	4·56

The water contained is believed to be mechanically present in the pores of the scale, and not chemically dissolved. Of course, marine boilers are scaled as often as it can be done; but, for long voyages, it is often out of the question. Starting with 20 lbs. pressure in the boiler, and clean fires, it is generally found that, on the second or third day, in spite of greater exertions of the stokers and harder firing, only 19 lbs. or less, can be kept constantly, and this loss in efficiency goes on at an increasing rate. In eight days' constant steaming it has been found (in one instance) that, starting with 22 lbs. pressure, the same was reduced to 15 lbs. at the end of the voyage; this, it is supposed, without at all forcing the firing. Take another instance at random, the *Persia* log, from the year 1858, September 30 to October 9, inclusive: Total number of nautical miles traveled, 2886; total quantity of coals consumed, 1402 tons. But whereas the consumption of coals per hour per indicated horse power was 3·95 on 30th September, (she left New York on the 29th,) it had increased to 4·314 on the 8th of October, (*Artizan*, May, 1860.) These few items illustrate sufficiently the well-known fact that incrustation, even only as thick as paper, has a very great and perceptible influence tending to counteract the economy of fuel.

As to durability, marine boilers, with all care, on an average, only last five years; but this is chiefly owing to internal and external corrosion, rendered more intense by the salts contained in sea-water, which, besides, promotes galvanic action in various ways. This must be understood to apply to boilers properly managed; that is to say, in such a way that only a very thin scale is allowed to be formed; for, as mentioned above, if thick scale is formed anywhere in places exposed to the heat of the furnace, or the escaping gases, this circumstance contributes directly to the burning away or oxidizing of the

* This is, however, overrating the case considerably.

plates. This fact, that marine boilers wear out so quickly, must, as far as can be seen at present, remain unaltered so long as salt water is employed, and, in spite of repeated trials, and more or less success of surface condensing, in some instances, still we are far from the general introduction of surface condensing, and, considering the vast number of marine engines in existence worked with common injection condensers and salt water in the boilers, leaves the importance of the subject under consideration intact. It is now proposed to give a general explanation of the action of sea-water as it obtains in the marine boiler. The specific gravity of sea-water varies according to different localities; and calling that of pure distilled water 1000, the average specific gravity of sea-water, according to Farraday, is 1027. For sea-water of the specific gravity of 1027·2, such as he used in his experiments, one cubic foot weighs 64·1416 lbs., or 1026·265 ozs. avoirdupois, and contains of

	Ounces.
Chloride of sodium, or common salt	25·762
Muriate of magnesia	3·282
Sulphate of magnesia	2·212
Sulphate of lime	1·013
Total	31·269

besides small quantities of other salts, but too minute to be of any consequence.

Dr. Ure found the largest proportion of salt held in solution in the open sea to be 38 parts of 1000, and the smallest 32. The Red Sea, however, contains 43 parts in 1000; the Baltic contains 6·6; the Black Sea 21; the Arctic Ocean 28·5; the British Channel 35·5, and the Mediterranean 38.

The following table shows the boiling point and specific gravity of water of different densities at a barometric height of 30 ins. of mercury:

	Saltness.	Boiling point.	Specific gravity.
Pure water	0	212°	1·000
Common salt water	1-32d	213·2	1·029
	2-32d	214·4	1·058
	3-32d	215·5	1·087
	4-32d	216·7	1·116
	5-32d	217·0	1·145
	6-32d	219·1	1·174
	7-32d	220·3	1·203
	8-32d	221·5	1·232
	9-32d	222·7	1·261
	10-32d	223·8	1·290
	11-32d	225·0	1·319
	12-32d	226·1	1·348

The deposit of salt begins at a density of 4-32d, and at 12-32d we have arrived at the point of saturation, or the point at which water is incapable of dissolving any more. According to M. Cousté, an im-

perial gallon of water is capable of holding in solution at 60° Fahr. and at boiling point, viz: in the open air, the following weights, nearly:

	60° Fahr.	Boiling point.
Carbonate of lime	Merely traces.	Merely traces.
Silica	70 grains.	" "
Sulphate of lime	170 "	" "
Carbonate of magnesia	3·25 ounces.	" "
Sulphate of potassium	10 "	40 ounces.
Chloride of sodium	32 "	30 "
Chloride of magnesium	266 "	580 "
Nitrate of lime	500 "	580 "
Chloride of lime	540 "	unlimited.

The order of deposition in the boiler as the water becomes concentrated is: 1st, carbonate of lime; 2d, sulphate of lime; 3, the salts of iron and oxides, and some of those of magnesia; 4th, the silica or alumina usually with more or less organic matter; and 5th, chloride of sodium or common salt. Now, it is well known that sulphate of lime is the worst of all the salts in a marine boiler. We have seen that 12-32d, or 37 in 100, is the point of saturation for common salt, but in the case of sea-water, which contains other salts besides, 36 parts in 100 saturate at 226°, and 30 in 100 at 228°. Now, taking 20 lbs. pressure, which is the most prevailing now, this, with a saturation of 3-32d to a rise of 1·2° per 1-32d, according to Professor Rankine, corresponds to a temperature of (say) 262·9° Fahr. How much salt can be held in solution at that temperature is not known to the author; but it is well known that the quantity decreases with increased temperature, and this is the reason of our not having yet arrived much beyond 20 lbs. pressure in marine boilers working with salt water. In marine boilers we have chiefly to do with sulphate of lime, the proportion of the same so largely preponderating in the incrustation on analysis. As to carbonate of lime, this enemy to boilers is, fortunately, not a constituent of salt water, except in the Mediterranean, which contains a trace of it, (·001 in 100 parts.) Sulphate of lime forms deposits at all temperatures and at all densities. Salt, on the contrary, forms deposits, as we have seen in the foregoing, not to any extent except when in the quantity of 3-32d or 4-32d, the quantity of the same required for saturation decreasing with increased temperature, and the amount of deposit that will take place long before the point of saturation having been arrived at increasing with increased temperature or pressure. Sulphate of lime will deposit at any temperature; but it so happens that increase of temperature also increases the amount of deposit of this salt; for, according to M. Cousté, the solubility of sulphate of lime at different temperatures is as follows. The table indicates the solubility for different temperatures as well as degrees of concentration at which the saturation of sulphate of lime takes place:

Degrees of ærometer corresponding to the saturation.	Temperature.		Total pressure in atmospheres.	Solubility, or proportion of sulphate of lime in 100 parts of water at saturation.
	Fahr.	Cels.		
12½	217·4	103·00	1	·500
12	218·84	103·80	1	·477
11	221·27	105·15	1	·432
10	227·48	108·60	1¼	.395
9	231·8	111·00	1¼	·355
8	235·76	113·20	1½	·310
7	240·44	115·80	1½	·277
6	245·3	118·50	1¾	·226
5	250·	121·20	1¾	·183
4	255·2	124·00	2	·140
3	261·68	127·60	2	·097
2	266·	130·00	2½	·060
1	271·94	133·30	2½	.023

Now, this table, and that of the amount of salt which can be held in solution at high pressures (say 20 lbs.), a table, the author believes, not to be found anywhere, would give us as near as possible the quantity of water that ought to be blown out of a boiler to prevent, first, accumulation of chloride of sodium, and second, the deposition of sulphate of lime in any quantity injurious to the boiler in any high degree. True, there is one way of getting over the difficulty, viz: working with a lower pressure; but this is out of the question for several reasons, and we must hence use experience and experiments as our guide. From the foregoing, it will be clear that every pressure requires a different treatment and a different amount of water to be blown off. If you blow off more than is necessary to prevent accumulation of salt in the boiler, you have to pump a greater quantity of feed-water in, and consequently a greater amount of sulphate of lime in solution, which will be deposited as a hard tenacious scale. On the other hand, if you blow off too little, you will certainly get less sulphate of lime, but the accumulation of common salt will ultimately choke the passages in the boiler. This maxim, though true in theory, is modified in practice, because of disturbing elements, viz: the more or less rapid circulation of the water. To strike the just balance it is, as before said, necessary to be guided by experience. It seems that ignorance has prevailed in high quarters till very late years because of want of data. Thus we find that Mr. James Napier read a paper, in 1859, before the Institution of Engineers of Scotland, in which he recommended the use of a much larger generator, (a sort of tubular feed-water heater, the heat of the brine blown off being made use of for that purpose,) and blowing off to a greater extent than generally used. He tried the experiment himself, and gave the results in a paper, read February 17, 1854, before the same Institution. For the screw steamer *Lancefield*, trading regularly between Glasgow and the Hebrides, he made a regenerator of ten times the usual surface, and blew off to such an extent as to keep the density of the water in the boiler at very nearly the same point as the water in the sea. After

four weeks' running, the boiler was examined, and instead of its being clean and free from scale, he found, to his surprise, it was coated with a much thicker scale than under usual circumstances, but soft, like newly made mortar, but it dried and hardened before he could get it all out, and it was then nearly as difficult to scrape as the ordinary hard scale. On one voyage, when he was present himself, he gave the boiler as much feed as the pump would do, and he observed then that the water in the gauge-glass was muddy. He continued the experiment for six months, but with lesser quantities of feed, and blew off till the tubes of the regenerator gave way, and then he discontinued. He saw then M. Cousté's paper, and the table contained in the same, which shows that at two atmospheres pressure sea-water becomes saturated with sulphate of lime, even at the ordinary density, and as he loaded to 40 lbs., and generally worked at about 30 lbs., he saw at once the explanation of the phenomena. Although he blew off constantly from the surface by a conical tube, only some of the deposit of precipitate matter could be got rid of. This tallies exactly with the experience of some others. Some steamers in the American navy work with about or nearly 30 lbs. pressure and salt-water, but it is believed not with our ordinary tubular boiler, but with long cylindrical boilers, having large round tubes and very ample water-way. In the discussion following, Mr. Elder said he had worked marine boilers with 30 lbs. to 35 lbs. and salt-water. One naturally expected to find most deposit in that section of the boiler which contained most salt and lime, he said, but in a boiler divided into eighteen parts (supposed to refer to his spiral flue high-pressure boiler) he found that though in the last section there was $2\frac{1}{2}$ times more salt in the water than in that of the first section, yet the deposit of lime was about equal in all parts. He concluded that the amount of deposit of lime depended on temperature, and not quantity of lime in it. The Americans, he said, ran with 40 lbs. pressure, and did not appear to suffer from deposit, but they cleaned the boiler whenever they came into port. He found the deposit to be greatest where there was no current. He had observed boilers running with 45 lbs. for three or four months, and there was not much more deposit than when working with 25 lbs. He believed that there was a greater tendency for the lime to separate and deposit, but it did not necessarily settle down on the heating surface of the boiler.

The *Mechanics' Magazine*, in an article on "Incrustation in Marine Boilers," February 24, 1860,* mentions Mr. James R. Napier's paper, and assumes, for want of better data, 28 parts of sulphate of lime to 1000 of solution as the limit of saturation in boilers working at a pressure not exceeding 20 lbs., and finds that, with this assumption, half the water must be discharged to keep the boiler clean, and this is affirmed by the practice of the British and North American Mail Company and others. Mr. Thomas Rowan found that when he had evaporated $\frac{2}{10}$ and $\frac{4}{10}$ of the water, a trace of sulphate of lime deposited; $\frac{5}{10}$ of the water, sulphate of lime deposited in larger quantities; $\frac{6}{10}$ of the water, sulphate of lime decided in larger quantities;

* See *Jour. Frank. Institute*, vol. xl., 1860, page 297.

$\frac{8}{10}$ of the water, sulphate of lime in very large quantities, also magnesia, and salt began to form. It is probable, therefore, that half or more of the water would have to be blown off in order to prevent formation of crust. This means that the density of the water should be kept at $\frac{2}{32}$, for as sea-water contains $\frac{1}{32}$ in its pure state, it is evident that half the water must be blown off to keep it at double its natural density. It may here be remarked that a density of $\frac{2}{32}$ is very generally kept in marine boilers, using about 20 lbs. pressure of steam, and if this be constantly and carefully attended to, no considerable or deleterious thickness of scale accumulates, at least in places where the circulation is good.

(To be continued.)

Cost per Ton per Mile of Traction Engines.

From the London Mechanics' Magazine, March, 1866.

Experiments have recently been made with one of Messrs. Aveling & Porter's traction engines, to determine the cost per ton per mile of conveying goods by this means. The result of a carefully conducted trial trip of 26 miles showed that the total cost per ton per mile was 2·93*d.* This amount comprises 1·592*d.* per ton per mile for working expenses, and 1·338 *d.* for turnpikes, which must be taken as exceptional. The engine used was one of the pair recently employed to take the base of the Wellington Memorial from Reading to Strathfieldsaye, and the trial proved highly satisfactory, as the above figures indicate.

Fabrication of a Cement with a Basis of Plaster of Paris, or Gypsum.

From the London Builder, No. 1210.

The plaster is first burned or roasted, in the ordinary way, in an appropriate furnace, so as to drive off the water. After this, it is broken into small fragments, which are immersed in a solution of alkaline silicate, containing an alkaline carbonate. The solution which answers best is composed of silicate of potash, containing a sufficient number of equivalents of carbonate of potash, to avoid the precipitation of the silica, in the following proportions: 0·880 kilog. (1·94 lb.) of silicate of potash containing 0·255 kilog. (·56 lb.) of carbonate of potash, in 4·54 litres (a gallon) of water, a solution having a specific gravity of 1200, but which may vary according to the use for which the cement is intended. As, for example, it can be employed of the strength above indicated in a great many cases where the best quality is required; and, if an ordinary cement is only necessary, it can be diluted with two parts of water to one of the solution. If a cement be required to harden slowly, sulphate of potash may be added to the carbonate, so that the endurating action of the silica upon the plaster may thus be varied in tone at pleasure. After having left the plaster steeped in the solution for twenty-four hours or so, it is taken out and left to drain in a compact mass, in order that the diffusion of the solution through the plaster may take place more effectually; the cement

is then taken back to the furnace, and reheated to 150° or 250° C., (302° to 482° Fahr.,) to drive off all the water, after which it is ground to powder, and can be colored to any desired hue by mixing with a pigment.

On the Results of a Series of Observations on the Flow of Water off the Ground, in the Woodburn District, near Carrickfergus, Ireland; with accurately recorded rain-gauge registries in the same locality, for a period of twelve months, ending 30th June, 1865. By ROBERT MANNING, M. Inst. C.E.

Read before the Institution of Civil Engineers, April 24, 1866.

From the London Civil Engineer and Architect's Journal, June, 1866.

It was stated that the surface of the ground was chiefly composed of bare mountain pasture and grazing land, the surface rock being almost entirely tabular trap, overlying the chalk, with here and there patches of green sand. Three rain-gauges were placed at the respective elevations of 300 feet, 750 feet, and 900 feet above the level of the sea; and two stream gauges were erected, one on the southern branch of the river, which received the drainage of 2076 acres, and the other on the northern branch 1329 acres. The stream gauges were rectangular notches with sharp edges, such as were used by Mr. Francis, at Lowell, and the formula for calculating the discharge was that deduced from those well known experiments. The observations were nearly eight hundred in number, and were recorded in an appendix. From a summary of the results, it appeared that the rain-fall for the year was 35·867 inches, or nearly 18 per cent. above that of Belfast. For the six months, from November to May, the rain was 14·766 inches, producing a flow of 14·351 inches, while from May to November these quantities were 21·101 inches and 7·357 inches. The minimum flow off 1000 acres occurred in August, and amounted to 11 cubic feet per minute; the maximum, in September, to 3180 cubic feet per minute; and the mean monthly flow was at its minimum in July, and was 29 cubic feet per minute.

The particulars of one year's rain having been thus ascertained, it was assumed that the rain-fall on the Carrickfergus Mountains bore a constant ratio to that at Queen's College, Belfast, where a daily register had been kept for fourteen years, and that it was the greater by 16 per cent. The results then arrived at were, that the maximum rain-fall in 1852 was 47·71 inches, the mean for the fourteen years, 1851–64, was 38·42 inches, the average of the three dry years, 1855–56–57, was 32·76 inches, and the minimum in 1855 was 28·8 inches.

The question then remained, how much of this rain-fall was available for water supply? Twenty or thirty years ago, the evaporation was taken as proportional to the rain-fall, and was variously estimated at one-sixth, one-third, and two-thirds of the mean annual rain, according to circumstances. Now, the balance of opinion seemed to be that the amount of evaporation was not proportional to the rain-fall; that

it was either constant or within narrow limits, where there was an identity or similarity in the physical features of the districts compared; that it varied under different circumstances in this kingdom from 9 inches to 19 inches; and that its amount in any particular case must be left to the experience and judgment of the engineer.

The author calculated that the loss, or the difference between the rain-fall and the supply, which was the resultant fact of greatest importance to the engineer, varied in the Woodburn District from 11·79 inches to 15·16 inches, the mean annual loss being 13·71 inches. The supply ranged from 14·57 inches to 35·37 inches, the mean annual supply being 24·71 inches. The years of maximum and minimum supply were also the years of maximum and minimum winter rain. In the years of 1856 and 1857, in which the rain-fall only differed by 0·41 inch, the difference in the loss was 3 22 inches, arising from the fact of there being a winter rain-fall of 15·96 inches in the former, and of 22·03 inches in the latter year.

The particulars were then given of the storage required for all quantities, from the mean annual supply down to that of the minimum year, from which it appeared that to store the whole rain yielded by the Woodburn District, 24·71 inches, a reservoir capable of containing 431 days supply would be necessary; for the average of the three dry years, 18·28 inches, 132 days would be required; while for the minimum, 14·57 inches, 119 days would be sufficient. Diagrams were added, showing the storage worked out for each month of the fourteen years, and for quantities of 24·72 inches, 20 inches, and 18 inches, and showing the state of the reservoir for a supply of 24 inches for eleven years, and 20 inches for the three dry years. It was remarked that, although the water in store attained its minimum in different years, that minimum invariably occurred in the month of October, and that, as regarded the economical supply of water from the district under consideration, it would not be prudent to attempt to store a greater quantity of rain than about 10 per cent. over the average supply of the three dry years, provided the extent of the gathering grounds could be increased.

The question of water power was then incidentally alluded to, and it was remarked that, in dealing with useless and injurious floods, and in providing a town supply, care should be taken not to induce the destruction, by instalments, of the whole water power of the country, and injuriously to interfere with the natural regime of rivers. The proportion of the mean annual flow of both branches of the Woodburn River, from a rain basin of 4750 acres, applicable to the supply of Woodlawn Mills, was then determined, and the calculations and results were given in detail. The tables showed, that of the total flow off the ground, 21·71 inches, there was lost on Sundays and by floods 12·22 inches, leaving 9·49 inches, or nearly 44 per cent., available for the supply of the wheel, which was equivalent to 194 days full work during the year, or 1·78 times the mean flow of the stream. If the capacity of the wheel were reduced to 1·5 of the flow, it would work for 213 days, if to 1·25 of the flow for 218 days, and if just equal to the flow it would work 243 days.

Steel for Columns.

From the London Builder, No. 1211.

In France a few experiments were made some time ago by M. G. H. Love upon small pillars made of Turton's steel, and having rounded ends. These pillars were 1 centimetre, or 0·39 inch, in diameter, the lengths being ten, twenty, and thirty times the diameter. The steel of which the pillars were composed was found by experiment to have a tensile breaking strength of 108,500 lbs. per square inch. According to *Engineering*, the results show that, as in the case of cast and wrought iron, the resisting power of steel to compression decreases as the proportion which the length of the column bears to the diameter is increased; but this decrease in strength does not seem to be so rapid as in the case of the two first-mentioned materials. M. Love's own deductions are, that steel and cast iron columns, having a length of from one and a half to five diameters, offer about the same resistance to compression; whilst columns of wrought iron of the same proportions offer only about half such resistance. When the length of the column is increased to ten diameters, however, he considers that steel offers a greater resistance than cast iron, in the proportion of 41 to 31, the proportionate resistance of wrought iron being represented by 17. As the proportion of length to diameter increases, the resisting power of cast iron diminishes more rapidly than that of wrought iron, and that of wrought iron more quickly than that of steel, so that when the length reaches forty diameters, he estimates the strength of similar columns of the three materials to be in the proportion of the numbers 375, 562, and 1500. It is wrong to found a law upon so few experiments; but, if the data above given are confirmed by future trials, steel will prove a valuable material for resisting compressive strains.

Water-proofing Walls. By FREDERICK ROGERS, Captain R. N.

From the London Builder, No. 1212.

Observing in the *Builder* a notice respecting damp walls in outbuildings, allow me to suggest a probable cure.

While in Dorset, I was applied to by a lady for a remedy for the above, and as I had for many years been in the habit of applying "bright American varnish" with great success to very exposed woodwork, I recommended the lady to make an experiment on the part of her house where not much seen. On passing by a few weeks afterwards, I observed all the front glowing to an evening sky.

On inquiry, I found that the varnish had so well succeeded in a small way that the lady had applied the same to the whole building, with equal success; and, when afterwards painted, there was no appearance of wet or "varnish."

The "bright American varnish" is very inexpensive, costing, I think, about 3*s.* per gallon, and may be procured from most sea-ports. I should recommend one coat of varnish as a trial, and if not quite successful then another, followed by three good coats of paint.

On Uniform Rotation. By C. W. Siemens, F. R. S.

From the London Artizan, June, 1866.

The paper sets out with an inquiry into the conditions of the conical pendulum as a means of obtaining uniform rotation. This instrument, as applied by Watt to regulate the velocity of his steam engines, is shown to be defective, first, because the regulated position of the valve depends upon the angular position of the pendulums, and, therefore, upon the velocity of rotation, which must be permanently changed in order to effect an adjustment of the valve; and, secondly, because when the balance between force and resistance of the engine at a given velocity is disturbed, the angular position of the pendulums will not change until a power has been created in them, through acceleration of the engine sufficient to overcome the mechanical resistance of the valve, giving rise to a series of fluctuations before a balance between the power and resistance of the engine is re-established.

These defects in Watt's centrifugal governor are shown to be obviated in the chronometric governor, an instrument which was proposed by the author of the paper twenty-three years ago, and which consists of a conical pendulum proceeding at a uniform angle of rotation, and, therefore, at a uniform speed, which is made to act upon the regulating valve by means of a differential motion between itself and the engine to be regulated, which latter has to accommodate itself to the rotations imposed by the independent pendulum. The differential motion wheels are taken advantage of for imparting independent driving or sustaining power to the pendulum; and a constancy of the angle of rotation, notwithstanding unavoidable fluctuations in the sustaining power, is secured (within certain limits) by calling into play a brake, or fluid resistance, at the moment when the angle of rotation reaches a maximum, which maximum position is perpetuated by increasing the sustaining power beyond what is strictly necessary to overcome the ordinary resistance of the pendulum.

The chronometric governor is used by the Astronomer Royal to regulate the motion of the large equatorial telescope and recording apparatus at Greenwich, in which application a very high degree of regularity is attained; but the instrument proved to be too delicate in its adjustments for ordinary steam engine use.

After a short allusion to M. Foucoult's governor, the paper enters upon the description of a new apparatus which the writer has imagined for obtaining uniform rotation, notwithstanding great variations in the driving power, and which consists in the main of a parabolic cup, open at top and bottom and mounted upon a vertical axis, which cup dips, with its smaller opening, into a liquid contained within a casing completely enclosing the cup. It is shown that a certain angular velocity of the cup will raise the liquid (entering from below) in a parabolic curve to its upper edge or brim, and that a very slight increase of the velocity will cause actual overflow, in the form of a sheet of liquid, which, being raised and projected against the sides of the outer chamber, descends to the bath below, whence fresh liquid continually enters the cup. Without the overflow scarcely any power is required

to maintain the cup, with the liquid it contains, in motion; but the moment an overflow ensues, a considerable amount of power is absorbed in raising and projecting a continuous stream of the liquid whereby further acceleration is prevented, and nearly uniform velocity is the result. When absolute uniformity is required, the cup is not fixed upon the rotating axis, but is suspended from it by a spiral spring, which not only supports its weight, but also transmits the driving power by its torsional moment. The cup is guided in the centre upon a helical surface, which arrangement has for its result that an increase of resistance or of driving power produces an increased torsional action of the spring, and with it an automatic descent of the cup, sufficient to make up for the thickness of overflow required to effect the re-adjustment between power and resistance, without permanent increase of angular velocity.

It is shown that the density of the liquid exercises no influence upon the velocity of the cup, which velocity is expressed by the following formula:

$$n = \frac{\sqrt{2gh\left(1 + \frac{\rho^2}{r^2 - \cdot 293\,\rho^2}\right)}}{2r\pi}$$

in which

n signifies the number of revolutions per second,
h the height of liquid from the surface to the brim of cup,
r the radius of the brim, and
ρ the radius of lower orifice of cup,

only the rigidity of the spring must be greater when a comparatively dense liquid is employed.

In order to test the principle of action here involved, Mr. Siemens has constructed a clock consisting of a galvanic battery, an electro-magnet, and his gyrometric cup, besides the necessary reducing wheels and hands upon a dial face, which proceeds at a uniform rate, although the driving power may be varied between wide limits, by the introduction of artificial resistances into the electrical circuit. The instrument appears, therefore, well calculated for regulating the speed of all kinds of philosophical apparatus, and also for obtaining synchronous rotations at different places for telegraphic purposes. One of its most interesting applications is embodied in the "gyrometric governor" for steam engines. This consists of a cup of 200 millimetres diameter and the same height, which is fixed upon its vertical axis of rotation, and is enclosed in an outer chamber, containing water in such quantity that the lower extremity of the cup dips below its surface. The upper edge of the rotating cup is, in this application, surrounded by a stationary ring armed with vertical vanes, by which the overflowing liquid is arrested and directed downward, causing it to fall through a space or zone which is traversed by a number of radial and vertical blades projecting from the external surface of the rotating cup, which, in striking the falling liquid, project it with considerable

force against the sides of the outer vessel, at the expense of a corresponding retarding effect on the cup, increasing its regulating power.

The cup-spindle carries at its lower extremity a pinion, which gears into two planet-wheels at opposite points, which on their part gear into an inverted wheel surrounding the whole, which latter is fastened upon a vertical shaft in continuation of the cup-spindle, and is driven round by the engine in the opposite direction to the motion of the cup. The two intermediate or planet-wheels are attached to a rocking frame supported, but not fixed, upon the central axis, which wheels, in rotating upon their studs, are also free to follow the impulse of either the pinion or the inverted wheel to the extent of the differential motion arising between them. The rocking frame is connected to the regulating valve of the engine, and also to the weight suspended from a horizontal arm upon the valve-spindle, tending to open the valve and, at the same time, to accelerate the cup to the extent of the pressure produced between the teeth of the planet-wheels and the pinion, while the engine is constantly employed to raise the weight and cut off the supply of steam. The result is that the engine has to conform absolutely to the regular motion imposed by the cup, which will be precisely the same when the engine is charged with its maximum or its minimum of resisting load.

The paper shows that the action upon the valve must take place at the moment when the balance between the power and load of the engine is disturbed, and that the readjustment will be effected, notwithstanding a resistance of the valve exceeding 100 kilogrammes—a result tending towards the attainment of several important objects.

Messrs. Phillips' Patent Girders.

From the London Builder, No. 1204.

For some time past several interesting experiments on rolled iron beams of peculiar construction, have been progressing at Mr. Kirkaldy's works, Southwark, of which our readers may desire to have some particulars. Mr. Kirkaldy's machine (a patent,) we may say at starting, is a beautiful work, from the foundry of Greenwood & Batley, of Leeds.

Several years have elapsed since the continental architects and builders began the adoption of rolled iron beams in place of the ordinary wooden girders and joists, and found advantages in the substitution, not only in respect of cost, but also in the facility they obtained for working out conceptions which never could have had an actual existence under the old mode of construction.

Now, why have we not more generally adopted the use of so convenient a material as rolled iron? Years ago we suggested to the government the offering of a large premium for improvements in the mode of rolling iron. The fact is, that, with our practical habit of regarding things, the builder is popularly believed to be the best judge

of what is necessary. He is supposed to be, at least, practical; and the opinions of such a one will tell with people, in spite of the representations of architects,—men specially educated to discriminate between the fitness and unfitness of things for the purpose intended. And so we find that, although every architect knows cast iron girders are really dearer than wrought iron girders, inasmuch as they require more than double the weight to furnish equal strength, and even then that cast iron girders cannot be relied on through defects inherent in their manufacture, yet at this very moment we may behold them placed in more than one costly erection progressing in the metropolis, introduced, we suppose, for some consideration for client's whim or builder's convenience. But, although it is a fair subject of inquiry why the use of rolled iron has not received more attention at our hands, it may be stated at the outset that the vast improvement of riveted plate joists and girders over any of the preceding kinds of cast iron or wooden beams in use, and the facilities existing for their construction, justified their retention till it could be demonstrated that a better thing was at hand to replace them.

Few departments of engineering have had the benefit of actual experiments to the same extent as this one of girder construction. Witness the labors of Professor Hodgkinson, Mr. Fairbairn, and others; yet, till recently, we were without any definite knowledge of the properties of the rolled beams and their combinations. Mr. Homan, while engaged in making a series of tests for the purpose of obtaining reliable data for practice, noticed the tendency of all these beams to yield laterally before their full resistance was developed, and sought to obtain the required lateral resistance by riveting a plate on the top flange. Every previous experiment showed that, by supporting the beam back and front in such a manner that it could only yield vertically, the load might be increased 40 per cent. Thus a beam 8 ins. deep, with flanges $2\frac{1}{2}$ ins. placed on supports 20 ft. apart, sustained about 4 tons on the centre before yielding sideways and becoming crippled; while the same beam "cradled," or supported laterally, took $5\frac{1}{2}$ tons before breaking. After the plate had been riveted on the top flange, the same kind of beam took 7 tons without showing the slightest fracture, and merely exhibiting a considerable set vertically. Other results were obtained equally striking. By doubling the depth of a beam, we double the resistance, other things being equal; and so, when increased strength beyond that furnished by one beam was required, it was usual to place two together, either alongside or on each other; for example, if one beam were equal to 4 tons, two beams were equal to 8 tons, and experiment showed that such was actually the case. Two of these beams, 8 and $2\frac{1}{2}$, were, therefore, riveted together, one upon the other, and the lateral deflexion was sought to be remedied as before by riveting a plate, 8 ins. wide by $\frac{3}{8}$ thick, on the top flange. The beam now formed was 16 ins. deep, and it was expected to be equal to 10 tons on the centre, when placed as before on supports 20 feet apart. On applying the strain it was found that 16 tons produced no sensible set, and at 20 tons the beam failed only by lateral twisting,

the iron being sound and uninjured. Here, then, was a novelty. We have examined the various authorities on this subject of beams, and have conversed with several persons who have had great experience in designing girders, without finding any notice or previous knowledge of this singular result; indeed, it is useless to attempt to understand the properties of these girders on any ordinary hypothesis. The real explanation probably lies in the fact that the web-plate, usually considered as not contributing to the strength of the riveted plate girders by reason of the attachment to the flanges being merely mechanical, actually enters into the work of the patent girders, united as it is to the flanges by the superior attachment of the natural cohesion of the metal. Taking, then, the web of these girders as forming an important element in their ultimate resistance, we are able to understand and accept as probable what would otherwise appear extraordinary. In order to arrive at their relative value, compared with the ordinary riveted beam, we will apply the well-known formula of Mr. Fairbairn, $w = \frac{adc}{l}$, where w = weight, a = area of lower flange, d = depth of girder, l = length, and c is a constant, the value of which depends on the form of beam, and must be ascertained by experiment; whence it follows that the higher the value of c, the greater the value of the beam for the same sectional area. A simple web-plate, with angle-iron on top and bottom, gives a constant of 60; an additional plate on the top and bottom flanges increases it to 75; that is, the strength of the girder is increased in that ratio. A box-beam, or cellular girder, gives a constant of 80, and these respective values are singularly correct when applied to ordinary iron and workmanship; if any deviation is found the cause exists in altered conditions, whether in the quality of the metal or workmanship. We use this formula because it is based on actual experiments, and for years has stood the test of practice; moreover, we understand that it applies with great consistency to the new form of girder. We have said that Mr. Fairbairn's experiments established the values of riveted girders at 60, 75, and 80, the difference depending on their form. The rolled beams made by the Butterly Company give 57 to 88 as constants; the tests we have seen applied to the Belgium beams give higher results; but the difference probably depends on the fact, that the flanges were smaller, and the distribution of the metal such as to enable a larger amount of work to be done in proportion to the sectional area.

Among the experiments recently made at Mr. Kirkaldy's works, we will take two, as best illustrating the subject, and will compare them with the given results of riveted plate girders of corresponding sectional area, and consequently of a like weight per foot run. A rolled beam, 8 ins. deep, with lower flange of 2½ ins., and with a plate 6 ins. by ⅜ in., riveted on top flange, the whole weighing 22 lbs. per foot run, was placed on the machine at 20 ft. distance between the supports. Now, if we had to design a riveted plate beam of corresponding weight, and if we were seeking the best distribution of the parts, with the view of obtaining the greatest amount of strength, we should make the web-

plate 9 ins. by $\frac{1}{4}$ in. thick, the bottom angles 2 ins. by 2 ins. and $\frac{3}{16}$ in. thick, and the top angles heavier, to equalize the compressive strain of the top flange with the tensile strain of the lower flange, say, 2 ins. by 2 ins. and $\frac{5}{16}$ in. thick. Such a beam, weighing 22 lbs. per foot run, would break with about $3\frac{1}{2}$ tons applied on the centre, with a span of 20 ft. A strain of 4 tons was at once applied on the centre of the patent beam, and after a short time withdrawn, without any appreciable set; 5 tons were then applied, and on being withdrawn a set to the extent of $\frac{3}{16}$ in. was found to have taken place. The load was then increased to 6 tons and 7 tons, the set increasing to 4 ins., but without the least fracture or injury to the beam beyond the set in the centre. If we now apply the formula to find the constant, taking area of flange at 1 in., we have $c = \frac{wl}{ad} = \frac{7 \times 240}{1 \times 8} = \frac{1680}{8} = 210$, and this figure indicates the value of the constant in the formula $w = \frac{adc}{l}$. The second illustration presented was a girder formed of two similar beams, of 8 ins. depth by $2\frac{1}{2}$ ins. width of flange, riveted together, with a plate on the top flange of 8 ins. width by $\frac{3}{8}$ ins. thickness, the whole weighing 40 lbs. per foot run.

For a corresponding sectional area of ordinary riveted girder, we may take a web plate of 12 ins., with bottom angle-irons of 3 ins. by $\frac{1}{4}$ in. thick, and top angles of 3 ins. by $\frac{1}{2}$ in. thick, to equalize the strains as before. Such a girder would weigh 40 lbs. per foot run, and would break with 9 tons applied on the centre. The patent girder was placed at 20 ft. between supports, like the first, and 10 tons weight applied on the centre, without even a perceptible deflexion, although the delicate register of the testing machine showed deflexion, and even set, in an infinitely small degree, when the weight was removed. The weight was then increased successively to 12, 14, and 16 tons, the set registered at this last weight being $\frac{1}{8}$ in., and ultimately increased to 20 tons, when signs of yielding by compression were apparent near the upper part of the web-plate. On attempting to increase the strain it became evident that the girder could not be broken, although by twisting a severe crippling might result. Again applying the formula to ascertain the constant, $c = \frac{wl}{ad} = \frac{20 \times 240}{1 \times 16} = \frac{4800}{16} = 300$, we obtain a constant of 300, against the riveted beam of similar sectional area taken at 75.

The profession will probably desire to see some of these girders tried against girders of the old forms, made of similar iron, and under the same machine, before they admit a great superiority. Enough, however, has certainly been shown to encourage the Messrs. Phillips to persevere in bringing the invention prominently before the public.

On the Performance, Wear, and Cost of Maintenance of Rolling Stock.

By T. A. Rochussen, Assoc. Inst. C. E.

Read before the Institution of Civil Engineers, April 24, 1866.

From the London Civil Engineer and Architect's Journal, June, 1866.

This communication related to the statistics of three Prussian railways—the Cologne-Minden, the Bergish-Maerkish, and the Rhenish—the general circumstances of which were stated to be somewhat similar. The tables embraced the particulars of the engines, and of the carriages and wagons, with the expense of repairs and renewals, the work done by the engines in 1864, the cost of motive power, the repairs and renewals of engine-tyres, and the commercial results. Also the experience of the wear of tyres on the Cologne-Minden Railway for the twenty years, from 1845 to 1864, inclusive, embracing the results of observations upon about twenty-five thousand tyres of different makes and of different materials.

It was stated that, on the Prussian railways, the iron-spoke wheels were gradually replaced by disc wheels, which at first were of wood, but latterly they were entirely of iron. The first form of iron disc, adopted in 1848, was that of a bulged star; a wrought iron plate, flanged to form the periphery of the wheel, was indented with five triangular bugles from the boss, which was cast on the plate forming the disc. This wheel had proved to be very durable, but it was noisy, and, the boss being 11½ inches in diameter, the structure was heavy. It, however, supported the tyre evenly and well, and reference was made to a pair of these wheels with iron tyres, which had run 116,000 miles without requiring turning, and, being still 1⅝ inch thick, it was thought they would last up to 250,000 miles. In 1862, a dished wrought iron disc wheel was introduced, the manufacture of which was both cheap and expeditious. But the fine grain iron necessary to insure a sound flanging for the periphery of the wheel made it too rigid. Attention was then directed to the means of obtaining elasticity both in the form of the disc and in the material used. Accordingly, fibrous iron was employed, and the flat or dished disc was corrugated, the periphery being formed by a rim of fine grain angle-iron, riveted to the disc plate. Subsequently the disc and the rim were welded together, and about the same time the Bochum Company introduced steel castings, in the corrugated form, of combined disc and tyre. In the improved form of the corrugated wrought iron disc, brought out in 1864, the iron used was highly fibrous. Several slabs were forged to the shape of a double cardinal's hat. This bloom was reheated twice, and, by frequent and quick rolling, was enlarged to about three feet in diameter. The rim was welded on under the steam hammer, which, at the same time, punched the hole in the boss for the axle, and gave the form of the wave to the disc plate. After turning up the rim, the tyre was shrunk on and bolted. Since 1864, the tyre, whether of steel or of iron, had been welded on to the disc wheel by hydraulic pressure. In this form, it was believed, the disc wheel offered the greatest amount of strength: the fibrous iron gave elasticity, the tyre was supported

in every part, there were no joints, bolts, or rivets to wear loose, and after the tyre had been worn out, it was simply necessary to turn it down to the thickness of an ordinary wheel rim, and to shrink on another tyre. It was asserted that, with steel tyres, these wheels would run from 300,000 to 500,000 miles before requiring a new tyre, and that by grinding the tyres instead of turning them their life would be prolonged from 50,000 to 60,000 miles.

The Great Forth Bridge.

From the London Mechanics' Magazine, June, 1866.

This bridge has been designed for the purpose of enabling the North British Railway to cross the Firth of Forth between Blackness and Charleston, about fourteen miles west of Edinburgh. On account of the peculiar nature of the bottom, however, before the bridge-works are commenced, an experimental pier will be constructed, which is to be built on a raft as a foundation. This raft, which was launched on June 14 inst., at Burntisland, consists of a mass of parallel logs of Memel timber, bolted together on a series of cross-beams. It is 80 feet by 60 feet, and 7 feet thick, and its superficial area is 4800 feet. The bottom on which this raft will be placed is of silt, which has been bored to the depth of 120 feet. The idea is, that by giving this broad platform or rest to the structure, a secure foundation may be obtained even on that slimy bottom, and on the success of the first pier, so founded, the hopes of the bridge may be said to rest. The raft is intended to be towed to the site of the proposed pier and the building carried on within a caisson, of which the bottom line is already laid upon the raft. Outside the caisson are eight cylinders to be loaded with iron when the raft is sunk. The caisson is trapped with apertures, which will enable the divers to get below the raft for filling up or otherwise perfecting the foundation. The building will be carried upwards from the raft to 12 feet above high water-level, and, the depth being 40 feet, this will give 52 feet of brick-work from the surface of the raft. The greatest diameter of the masonry will be 50 feet, declining to 27 feet, and the thickness 7 feet, the outline resembling the figure 8. The mooring of the raft will be effected by two barges of 700 tons burthen, fitted inside as dwellings for the workmen, and the decks being a platform for materials. After the raft is moored, the masonry will be proceeded with, and as the work goes on and the platform settles down, the walls of the caisson will be carried up, so as to keep out of the water. When the silt is reached by the gradual depression of the raft, the cylinders will be loaded with 10,000 tons of pig iron, about 2½ times the ultimate weight of the bridge upon the pier, so as to press the foundation into the silt, and also to secure a perfectly horizontal position. When the iron load has effected its purpose, the cylinders will be emptied and removed. The Forth bridge, which is designed by Mr. Thomas Bouch, C. E., Edinburgh, and is estimated to cost about half a million, will, should it be carried out, be 2¼ miles long. It will be a lattice girder bridge, resting on 61 piers, and with four spans of 500 feet each, which will be 125 feet above high water-level in the centre.

Each of the four girders will weigh 1170 tons, about 592 tons less than the tubes of the Britannia bridge, though the span is 40 feet greater. The depth of the girders will be 64 feet and the width 18 feet. The height of the bridge from foundation to top of girder will be 212 feet. It is not intended to proceed with any further preparation for the bridge until the success of the experimental pier be fully ascertained.

MECHANICS, PHYSICS, AND CHEMISTRY.

Failure of Chronometers. By Mr. William Ellis, F.R.A.S.

From the London Mechanics' Magazine, June, 1866.

In the course of a lecture on the treatment of chronometers, at the Greenwich Observatory, which was delivered in March last before the members of the British Horological Institute, by Mr. William Ellis, F.R.A.S., the lecturer gave the following as the conclusions at which the Astronomer Royal had arrived with regard to the chronometers examined. They are instructive as pointing out the causes of failure in otherwise unexceptionable instruments. The Astronomer Royal states that the material workmanship of all the chronometers is very good, and amongst nearly all the chronometers there is very little difference indeed in this respect. In uniform circumstances of temperature every one of the chronometers would go almost as well as an astronomical clock. The great cause of failure is the want of compensation, or the too great compensation, for the effects of temperature. Another very serious cause of error is brought out clearly in the trial, namely, a fault in the oil, which is injured by heat. This is very different with the chronometers of different makers. For instance, the oil used by one chronometer-maker is not at all injured by heat; while some of that used by another chronometer-maker is so bad that, after going through the same heating as those of the first-mentioned maker, the rates of the chronometers are changed (on returning to ordinary temperature) by eighty seconds per week. The Astronomer Royal asserts his belief that nearly all the irregularities from week to week, which generally would be interpreted as proving bad workmanship, are in reality due to the two foregoing causes.

When it is considered how very important is the compensation adjustment, it can never be out of place to enforce attention in this particular. Chronometers in which it has not been well attended to cannot come out well in the Greenwich lists, neither will navy chronometers, after repair, pass the Observatory test unless the compensation has been adjusted within close limits. There seems to be a want in London of some establishment to which chronometers might be sent for the purpose of being tested on the same terms as at Liverpool, at which place an observatory has long been established (under the direction of Mr. Hartnup) principally for this especial work. Any person can send a chronometer to the Liverpool Observatory to be tested, on payment of a certain fee; and one feature of the test is a rigorous trial of the compensation. Some such establishment was once started in London, but did not, from some cause, succeed; possibly its existence did not

become sufficiently known. We commend this matter to the careful consideration of the Horological Institute.

For the Journal of the Franklin Institute.

Force and Work. By FRED. J. SLADE.

The inquiry of "W." in the June number of the *Journal*, respecting an apparatus for illustrating force, appears to spring from a misapprehension of the distinction between force and work, which, it is believed, is common to many minds, and on that account deserving of attention.

A force may be resolved into components of any magnitude, either greater or less; a given quantity of work, however, can neither be increased nor diminished. Force is a simple element, and may be produced without cost; work, on the other hand, is the product of force and space, and can only be obtained by the expenditure of some equivalent.

Force *alone* produces no effect on bodies; it is only when it is exerted through space, and becomes work, that it effects a change in the state of objects.

This is the distinction that it is important to have clearly in the mind. If, in "W.'s" diagram, we suppose the point o to be acted upon by a force of one pound in the direction o *b*, the points *a* and *c* will each be acted on by a force of 5 lbs.; but if, now, we suppose o to begin to move under the influence of the force, (the force by associating with itself, the element space becoming work,) we see that the agent that is capable of producing this effect will be able and only able to move the points *a* and *c* each through one-tenth the distance in the direction *a* o and *c* o, with five times the force, the product or work done being the same.

So far we have said nothing of moving a weight, because here again there is often confusion of ideas. Work may be performed in a body in two ways; first, by *lifting* it through a certain space; or, secondly, by imparting velocity to it. We cannot speak of moving a body from one point to another in a horizontal direction as a measure of work, since work can only be expended in that case in the production of velocity, and the work performed will, therefore, not be measured by the distance moved through, but by the velocity *imparted* to the body. If the body already have a certain velocity, and that be not increased, it will move through the distance without the consumption of any work.

From what has been said, it will be seen that it is impossible for an amount of work that is only capable of lifting a body through one foot to lift two bodies, each of half the weight, through five times the height; nor, again, if capable of imparting only a certain velocity to a body can it, by any transformation, impart five times that velocity to two bodies of half the weight.

"W." is not the first who has failed to observe the distinction be-

tween force and work. We have known of a whole life-time being expended in the persistent effort to develop an invention based on this error, the inventor, though apparently a man of considerable study, being unable, from long habit of thought, to perceive his mistake when pointed out to him.

Mr. Hicks' Experiments on the Friction of Leather Collars in Hydraulic Cylinders.

For the Journal of the Franklin Institute.

An interesting paper in the June number of the London *Engineer*, details the experiments of Mr. John Hicks, C. E., and of Mr. Lüthy, an assistant engineer in his employ, to determine the friction of the leather collars or cup packing used in hydraulic presses. Very little has ever been published on this subject, and some gauges for high pressure have been made in which a plunger, packed in the usual manner, is used, in connexion with certain spring balances, to indicate the amount of pressure; and in these gauges the friction of the collars has been ignored. The instrument used by Mr. Hicks in prosecuting his investigation was one made with great care, and was capable of experimenting with plungers of various diameter, say from half an inch diameter up to 8 inches diameter. The testing plunger was made to pass through two packing rings of the same size, the pressure occurring between the rings. The plunger was thus balanced and could be moved back and forth with more or less ease, in proportion to the decrease or increase of the frictional resistance for the pressure of the fluid upon the packing rings. The experiments have been published in full, but we will only detail the

Result from the Experiments.—"The friction increases as the pressure increases. The frictions of the leathers for rams of different diameters, if the pressure per unit of area be the same, increases in direct proportion with the diameter, or with the square roots of the respective bolts.

"The depth of the leather does not affect the frictions on the ram." This latter assertion seems to have been made after quite a series of experiments had been tried with leathers of different depths, and the conclusion arrived at that "the whole friction is produced just where the leather emerges from the hollowed part of the groove and begins to lean against the ram."

From the experiments they have deduced the following formula:

$F = D \times P \times C$ in which P = pressure per square inch; C = a co-efficient = 0·0471 if leathers are new or badly lubricated, or = 0·0314 if leathers are in good condition and well lubricated, and D = diameter of ram.

Where pressure per circular unit is given, the formula remains the same as the co-efficient $C = \cdot 06$ for bad lubrication and ·04 for good.

The annexed table gives, in a compact form, the frictional resistance in per centage of the total hydraulic pressure for rams from 2 inches up to 20 inches diameter.

D inches.	F per cent.	D inches.	F per cent.
2	2·00	11	0·38
3	1·33	12	0·33
4	1·00	13	0·30
5	0·80	14	0·28
6	0·66	15	0·26
7	0·57	16	0·25
8	0·50	17	0·23
9	0·44	18	0·22
10	0·40	19	0·21
...	...	20	0·20

In the above, the friction on a ram 4 inches diameter is given as one per cent. of the gross load.

In forty-eight experiments the friction varied from one per cent. to 0·5 per cent., variation being ½ per cent.

In some experiments made in this city by Messrs. Wm. Sellers & Co., in hydraulic testing machines, they used as a gauge a steel plug, half an inch diameter, fitting into a steel collar of the same size. The collar in which the plunger moved freely was 3½ inches long, and this length of bearing was found sufficient to prevent the escape of oil under the pressure of 5000 lbs. to the square inch. They adopted this expedient for dispensing with packing from their knowledge of the variable frictional resistance of the leather collars.

They found, however, that although all packing was dispensed with, yet as the pressure increased a frictional resistance became manifested. It is now a matter of interest to determine, in a manner similar to the plan of Mr. Hicks, what is the rate of increase in frictional resistance, with plungers depending for their tightness, not upon packing, but upon long closely-fitted joints.

The Smithsonian Institute on the Ice on the Strainer.

In reference to an article published in the May number of this *Journal*, we publish the following as embodying the opinion of a competent authority. We think, however, that the views of Mr. Douglass are undoubtedly correct, and the hypothesis given by Prof. Henry, as of Arago, is insufficient to account for the facts:

UNIVERSITY OF MICHIGAN,
(Department of Chemistry.)
ANN ARBOR, *June* 13.

To the Editor of the Detroit Free Press:

The discussion of the subject of the accumulation of ice on the strainer at the waterworks will be recollected by many of your readers A few days since I received the following letter from Prof. Henry, the distinguished physicist at the head of the Smithsonian Institution:

SMITHSONIAN INSTITUTION, *May* 17, 1866.

My Dear Sir: In looking over the *Journal of the Franklin Institute* for the present month, I find your letter relating to the freezing of water around the mouth of an iron pipe at the depth of twenty-five feet below the surface. The fact is interest-

ing as a striking example of the production of "ground-ice," the explanation of which has been a puzzle to the physicist. The explanation which you have given is that which most readily suggests itself to those familiar with the experiments of Dr. Wells, and, indeed, is that which was most generally adopted previous to the researches of Melloni. He has shown that terrestrial radiation or heat of low intensity, is interrupted by the thinnest sheet of water. It is true, that the more intense rays of heat from the sun penetrate to a considerable distance below the surface of still water, but the less intense rays do not enter the water to any depth, and it is probable that by far the greater portion of a beam of solar radiation is stopped at the surface of water. Ground-ice is formed at the bottom of streams of running water, adhering to stones, grass, or other solid bodies. The explanation given, I think by Arago, is as follows: The water at the surface is cooled down below the point of congellation, when, by the motion of the water in the stream, it is brought into contect with a solid body at the bottom, which, acting as a nucleus of crystallization, immediately determines its solidification. This explanation will apply equally to the case referred to you, in which the water from the surface is drawn down by the discharge from the pipe. I think it probable that the whole subject requires further elucidation, and it is on this account I have taken the liberty to direct your attention to the facts I have stated.

JOSEPH HENRY.

PROF. DOUGLASS, University of Michigan.

The experiments of Melloni, as well as the explanations of Arago, of the formation of "ground-ice," I was familiar with at the time I gave my views last winter, but deemed them inadequate to the explanation of the singular phenomena, for the following reasons:

First. At 39·2° of temperature water has its maximum density. This is about 7° above the freezing point. The cooling takes place at the surface, and as the temperature arrives at 39·2° the cooled water would, by virtue of its diminished specific gravity, remain at the surface. I can scarcely conceive that the current of Detroit River, or the discharge from the pipe, would be sufficient to cause the water to descend twenty-five feet against the force of gravity.

Second. Why is it the ice ceases to form on the strainer as soon as the river is covered with ice, unless it is because the ice intercepts the radiation?

Prof. Henry is probably not aware of the moderate current of the river, or the fact last mentioned.

I send you the above letter from the distinguished Professor, that the public may know the intense interest that scientific men feel in the solution of this mysterious problem. I cannot but express the hope that the Water Commissioners will take measures to test the truth of these theories the coming winter.

S. H. DOUGLASS.

On Magnetical Errors, Compensations, and Corrections, with special reference to iron ships and their compasses. By Professor AIRY.

From the London Athenæum, April, 1865.

Prof. Airy has given three lectures "On Magnetical Errors," &c., at the old lecture theatre of the South Kensington Museum. These lectures were of so much importance as to deserve the utmost publicity.

The subject was treated under the following heads: I. Terrestrial magnetism and the magnetism of permanent magnets. II. Transient induced magnetism of iron. III. Sub-permanent magnetism of iron. IV. Correction of magnetic disturbing forces. V. Magnetism of ships, especially of iron ships, and correction of their magnetic disturbing forces on the ship's compass.

From the Professor's notes we give the following synopsis:

I. *Terrestrial Magnetism and the Magnetism of Permanent Magnets.*—1. Every magnet has two opposite poles, possessing different properties.

2. Every bar-magnet, when freely suspended, takes a definite position, one end pointing to the magnetic north. (The end which points

to the north is usually called the "marked end;" in the magnets used in the illustration of the lectures, it will be distinguished as the end painted *red*, the opposite end being painted *blue*.) In the following articles the words "north" and "south" are always understood as meaning "magnetic north" and "magnetic south."

3. The force which directs a magnet is not simply a force attracting the marked end towards the north horizon, or a force attracting the unmarked end towards the south horizon; but, if it consist entirely of attraction, is composed of equal attractions of those two kinds. It may consist, wholly or in part, of repulsion of the marked end from the south and repulsion of the unmarked end from the north; but if so, those repulsions are equal. Or, the north part of the earth may attract the red end and repel the blue with equal forces; or the south part of the earth may attract the blue and repel the red, but the forces must be equal. This is proved by the fact that the magnet, as a whole, is not drawn north or south.

4. The direction of one end of a freely suspended magnet towards the north will be used as the practical definition of the marked end of a magnet.

5. The marked end of one magnet repels the marked end of another magnet, whether it be presented sideways or endways. In like manner, the unmarked end of one magnet repels the unmarked end of another. But the marked end of one attracts the unmarked end of another, and *vice versa*. When a magnet cannot be conveniently suspended, this property may be used, with the assistance of another suspended magnet or compass, for distinguishing the blue and red ends. The points in which the attractive and repulsive powers appear to be concentrated are called the "poles of the magnet." It may be understood, without great inaccuracy, that the distance of each pole from the end of the magnet is about one-twelfth of the whole length.

6. A horse-shoe magnet is merely a bent bar-magnet, with poles possessing the same properties as those of a straight bar-magnet.

7. If above a large freely suspended bar-magnet a small magnet be freely suspended, when it is raised high it takes the same position as the large magnet; when it is lowered near to it it takes the opposite position, and at a certain intermediate height it is indifferent as to position, no force (apparently) acting on it at all.

8. These observations show that the magnetic attraction of the earth is similar in character to that of a bar-magnet, but that the part of the earth which resembles in its magnetism the marked or red end of a magnet is on the south side of the place of observation.

9. General principle of ascertaining the relative magnitudes of forces by vibrations of a suitable apparatus. The relative magnitudes of the terrestrial horizontal magnetic forces at different parts of the earth may be ascertained by observing the vibrations of the same magnet at different places. The forces thus found vary very greatly, being large near the irregular line called the earth's magnetic equator, and becoming insensibly small near the places called the magnetic poles of the earth.

10. In the preceding articles it has been supposed that the magnet

is constrained, either by the nature of its mounting or by the application of weights, to preserve a horizontal position, as it ought to do, in compass-cards, (the idea of allowing their needles to dip being totally erroneous.)

11. If the magnet is perfectly free, as in the instance of a dipping-needle, it takes a position inclined to the horizon; the marked end of the magnet is greatly depressed, pointing, at Greenwich, 68° below the north horizon, or much nearer to the vertical than to the horizontal direction. The direction thus taken by the free magnet is called "the direction of dip," and the plane perpendicular to it is called "the equatorial plane." (This "equatorial plane" is carefully to be distinguished from "the earth's magnetic equator," Article 9.)

12. Anticipation of the section on induction. Magnetization of a bar, or a reversion of its poles, by "double touch."

13. It is made certain, by reversing the poles of the dipping-needle, that the dipping is not produced by want of balance of the needle, but is a real result of the inclined direction of terrestrial magnetism.

14. At Greenwich, it is inferred from the direction of the dipping-needle, that the horizontal part of terrestrial magnetic force is less than the vertical part in the proportion of 40 to 99, that it is less than the whole inclined force in the proportion of 3 to 8, and that the vertical force is less than the whole inclined force in the proportion of 51 to 55; all very nearly.

15. Exhibition of the dips in different parts of a meridian of the earth. At the magnetic poles the dip is vertical, and there is no horizontal force. At the magnetic equator there is no dip. South of the magnetic equator the unmarked end of the needle dips. The magnitude of the total inclined force is rather less near the equator than in other parts of the earth, (it may be stated roughly as one-half of that near the magnetic poles,) but it is entirely effective in the horizontal direction.

16. Disturbance of a suspended magnet by a magnet placed below it. When the lower magnet has its marked end to the north, the directive force on the upper magnet is diminished; and when the lower magnet has its marked end to the south, the directive force on the upper magnet is increased, as is shown by its times of vibration.

17. If the lower magnet is made to rotate in a horizontal plane the position of the upper magnet is disturbed. During half the rotation the marked end of the upper magnet is turned somewhat to the east, and during the other half it is equally turned towards the west. The deviation vanishes when the lower magnet lies north and south, either way. The direction of disturbance is that given by the repulsion of similar poles or the attraction of different poles. This disturbance is sometimes called "semicircular deviation."

18. It is important to ascertain how this semicircular deviation will vary in different parts of the earth, (where, as stated in Article 9, the magnitudes of the terrestrial horizontal force vary greatly,) supposing the same lower magnet to be used, and at the same distance from the upper magnet.

19. Recourse must be had to the mechanical theory of "the com-

position of forces," the most important theory in the whole circle of sciences, and with which every student of any philosophical subject ought to be perfectly acquainted. Theorem of the "parallelogram of forces."

20. If with a primary force (as the terrestrial horizontal magnetic force acting on either pole of a magnet) there be combined a new force in a different direction, (as the force of the lower magnet acting on the same pole,) the direction of the resultant force will deviate from the direction of the primary (or terrestrial) force. But the greater is the primary force the smaller is the deviation. Thus, if a ship carries a magnet under or near her compass, this magnet will produce but a small deviation when the ship is near the terrestrial magnetic equator, (where the terrestrial horizontal magnetic force is large,) but will produce a great deviation in high magnetic latitudes, (where the horizontal magnetic force is small.)

21. If the lower or second magnet be not immediately below the upper or first magnet, but be on one side, whether at the same level or not, being, however, in the position "broadside on," and if its supporting frame rotate round the vertical axis of the first magnet, the deviation which it produces is semicircular, (see Article 17,) and vanishes when the second magnet lies north and south. The same holds when the second magnet is "end on." But if the second magnet is in an intermediate or inclined position, the deviation is semicircular, but the vanishing of the deviation occurs when the second magnet lies in a position varying from north or south.

22. But, supposing the second magnet to be lower, there is one important difference of these actions. If the first magnet is free to dip, then a second magnet broadside on will not cause the first magnet to dip, but a magnet end on, or nearly end on, will cause the first magnet to dip.

22*. The proportion of the actions of one magnet on another may be calculated with great accuracy by considering each magnet to consist of two centres of force (attractive or repulsive) near its extremities, acting on the similar centres of force of the other magnet, with equal force in all directions, varying inversely as the square of the distance. It results from this that, in any given direction of the line joining their centres, the directive force of one needle upon another varies nearly as the inverse cube of their distance.

23. The "astatic needle" is made by fixing two magnets of equal power on different parts of the same frame, with marked ends in opposite positions. The united frame is then insensible to terrestrial magnetism, but either magnet separately will be affected by the local action of a magnet near it.

23*. The astatic needle may be used to exhibit strikingly the effects of one magnet on another. Thus, if the external magnet be below or at the side of the lower needle of the astatic pair, the latter takes an opposite position as regards red and blue ends; but if the external magnet be moved, without change of direction, so as to present an end to the lower needle of the astatic pair, the latter immediately turns so as to take a similar position as regards red and blue ends.

II. *Transient Induced Magnetism of Iron.*—24. If a soft iron bar, which has not been subject to any special violence, be presented endways to the centre of a freely suspended magnet, the direction of the iron bar being either east or west in the horizontal plane, or any direction included in the equatorial plane, (see Article 11,) then no deviation whatever is produced in the magnet. If it be presented endways to either pole of the magnet, it slightly attracts that pole, (a fact to be explained below, Article 26.) It is indifferent which end of the iron bar be presented.

25. If a second magnet, with an iron bar in front, but separated by a small interval, be presented to the first magnet, and deviation be thus caused, then, upon causing the iron bar to touch the second magnet, the deviation of the first magnet is immediately increased, decreasing again when the iron is separated from the magnet. This shows that the contact of the second magnet has converted the soft iron, for the time of contact only, into a magnet whose poles are in the same relative position as those of the second magnet; and therefore a red pole of the second magnet produces a blue pole in that part of the iron which is next it, or *vice versa*. This production of magnetic power in iron by the action of an external magnet is called "induction."

26. This explains the attraction of soft iron by either pole of a magnet. For the magnet-pole, by induction, produces a pole of the opposite character in the nearest part of the iron; and between poles of opposite character there is attraction, (Article 5.)

27. If a bar of soft iron be held in a vertical position, then, upon raising and depressing it, it is found that the end which is lower repels the red end of the magnet and attracts the blue end, and the end which is higher attracts the red end of the magnet and repels the blue end. The bar has become a genuine magnet with red end downwards. But this magnetism is only transient; for upon inverting the iron bar the properties of its ends are inverted, and if it is placed in the equatorial plane (Article 11) they vanish entirely.

28. This is explained by induction produced by the powerful terrestrial magnetic force in the vertical direction, (Article 14.)

29. The amount of action depends, in some degree, upon the connexion of the parts of the mass of iron. The same mass in the same general form, but divided into several parts, produces a smaller effect.

30. If a mass, as a cannon-ball, be made to rotate round the suspended magnet in the same horizontal plane, it produces no disturbance when it is north, or south, or east, or west of the magnet's centre; but in the intermediate quadrants it produces deviation, changing its character in every successive quadrant, which may be represented (in memory) by saying that "the mass attracts that pole of the magnet which is nearest to it." This is called "quadrantal deviation."

31. The explanation is, that the induction produced by the horizontal part of terrestrial magnetic force converts the mass of iron into a horizontal magnet with red pole always towards the north. (A small magnet carried round always in that position produces a similar effect.) It is to be remarked, that the induction produced by the vertical part

of terrestrial force does not appear here, for a small vertical magnet carried round in the same manner produces no effect.

32. It may here be noticed that the quadrantal deviation thus produced in the compass by a mass of iron in the same horizontal plane is the same in all parts of the earth. For, referring to the parallelogram of forces, (Article 19,) if the "primary force" (which is here the terrestrial horizontal force) and the "new force" (which is here the force of the magnetism induced in the mass of iron) be always in the same proportion, the deviation for any definite inclination of the two forces is unaltered. Here they always are in the same proportion; because the magnetism in the iron, which is induced by the earth's horizontal force, is proportioned to it.

33. If the cannon-ball is higher or lower than the magnet, the deviation vanishes when it is north or south, but not when it is east or west, exhibiting a mixture of semicircular deviation (Article 17) with quadrantal deviation, (Article 30.) The former is produced by induction from the vertical part of the terrestrial force; it is exactly similar to the effect of a small vertical magnet (with red pole downwards, and with centre higher or lower than the deviated magnet) carried round the deviated magnet. The latter has been explained above, (Article 31.)

34. On further examination, it is seen that all effects are explained by induction in the cannon-ball, produced by the total terrestrial action in the direction of dip, converting the cannon-ball for the time into a magnet whose red end points down in the direction of dip.

34*. The law of disturbance may thus be represented (from memory). Through the centre of the magnet conceive an equatorial plane (Article 11) to pass. The mass of iron attracts that end of the magnet which is on the same side of the equatorial plane as itself.

35. Since the induced horizontal magnet (Article 31) has its red end in a position opposite to that of the earth, (Article 8,) it follows that one effect of the proximity of such a mass of iron at a lower level than the deviated magnet is, on the whole, to somewhat diminish the directive power of terrestrial magnetism.

36. The ordinary process of magnetizing a steel bar by double touch of two permanent steel magnets is a process of induction, differing from those of soft iron only in this respect, that the steel bar, when it has received the magnetism, retains it permanently.

III. *Sub-permanent Magnetism of Iron.*—37. When a bar or plate of soft iron, in a state of tremor from mechanical violence, is exposed to external magnetic action, it receives induced magnetism in the same manner as iron in a quiet state, (Articles 27 and 34;) but the induced magnetism is much more powerful, and is for a long time sensibly permanent. It does not change its direction on changing the position of the bar, (as in Article 27,) and it does not vanish in any position of the bar. The iron bar has become a true magnet, exactly similar in its action to a magnetized steel magnet. Its magnetism, however, diminishes sensibly in a few days or a few weeks, but a portion remains for many months or years. This has been called "sub-permanent magnetism."

38. The sub-permanent magnetism is most easily produced by striking an iron bar or plate under the action of terrestrial magnetism. The "magnetic anvil," consisting of two planes, one containing the direction of local dip, the other being the equatorial plane, (Article 11.)

39. If a bar or plate be placed on the dip-slope of the magnetic anvil, with its white end downwards, and be struck with a hammer, it becomes a powerful magnet, the white end having the properties of a magnet's red end, and the black end having the properties of a magnet's blue end.

40. If, now, it be reversed on the dip-slope with black end downwards, and be struck in the same manner, the black end has the properties of a magnet's red end, and the white end has the properties of a magnet's blue end, the power of the magnet being sensibly equal to what it was before.

41. If the bar, thus charged with sub-permanent magnetism, be placed on the equatorial slope of the magnetic anvil, and be struck in the same manner, all magnetism will sensibly disappear.

IV. *Correction of Magnetic Disturbing Forces.*—42. It is impossible to intercept the action of magnetic disturbing forces upon a magnet or compass by surrounding the compass, &c., with any substance whatever. Nothing is known which interrupts magnetic action, and if such a substance could be found, it would also interrupt terrestrial magnetic action, (which is of the same nature as the action of a magnet, see Article 8,) and the compass, &c., would be useless.

43. The only way of destroying the effect of one magnetic disturbing force is, to introduce another magnetic disturbing agent, whose force follows the same laws and has the same magnitude, but always acts in the opposite direction.

44. The disturbing effect of one magnet, or of several magnets, supposed to rotate round the compass, &c., in a horizontal plane, may be corrected by one magnet, or sometimes, more conveniently, by two magnets.

45. The disturbing effect of a mass of iron at the same level as the compass, which is quadrantal, (Article 30,) cannot be corrected by an equal mass on the opposite side; such an application would double the disturbance.

46. But it may be corrected by an equal mass at the position 90° distant, or by two smaller masses 90° distant each way, (and therefore opposite each other.)

47. It may also be corrected by placing another compass near to the disturbed compass.

48. The disturbance produced by an elevated or depressed mass of iron can be corrected by applying an equally elevated or depressed mass on the opposite side, which corrects the semicircular deviation, (Article 33,) but doubles the quadrantal deviation, (Articles 30 and 45,) together with a large mass 90° distant, or two masses 90° distant on each side, (either of which arrangements may be made to correct that doubled quadrantal deviation, see Article 46.)

49. Or it may be corrected by using a small magnet to correct the

semicircular part, (the small magnet being adjusted by trial to make the disturbance disappear when the mass is east or west,) and then applying a small mass or two masses 90° distant to correct the quadrantal part.

50. There is inconvenience in effecting, by a magnet, the whole or a part of the correction of a disturbance produced by terrestrial induction in masses of iron, (as is proposed in Articles 47 and 49,) because the action of the magnet is the same in all parts of the earth; whereas the disturbing force produced by induced magnetism in iron is proportional to the terrestrial force, which varies in different parts of the earth, (Article 9,) and whose direction relative to the horizon is in some places nearly inverted, (Article 15,) and thus the correction cannot be made universally effective.

51. The correction of the disturbing force of induced magnetism in one mass by the force of induced magnetism in another mass, (as is proposed in Articles 46 and 48,) is theoretically perfect in all parts of the earth, because both the disturbing force and the correcting force are proportional to the terrestrial force, and therefore they neutralize each other whatever be the magnitude and direction of that terrestrial force. This applies accurately to action on points near the centre of a compass, or applies very nearly to action on all points when the compass is small.

52. When the compass is large and has only one needle, the correction produced by a small mass of iron is not perfect, because it must be brought so close to one pole of the needle that the action on that pole is unduly large. But this inconvenience is almost entirely removed by use of the Admiralty compass with four parallel needles.

53. When the only correction to be effected is that of a quadrantal deviation, (Articles 30 and 45,) it may be abandoned entirely, provided that a compass-card with modified graduations be used; because the quadrantal deviation is the same in all parts of the earth, (Article 32,) and therefore the same modification of the compass-card which correctly alters the apparent card-reading in one part of the earth will correctly alter it in every other part.

(To be continued.)

Explosion of Steam Boilers.

From the London Mechanics' Magazine, April, 1866.

No. 7 explosion, by which one man was killed and five others injured, is an illustration of the unsatisfactory and dangerous character of plain cylindrical externally-fired boilers. This subject has frequently been called attention to in previous reports, but it is felt to be a duty to continue to do so as frequently as fatal explosions recur from the continued use of this class of boiler. The explosion in question took place at about quarter past ten o'clock on the morning of Monday, January 29, at a colliery which was not under the inspection of the Association. The boiler was about 30 ft. long, 6 ft. in diameter, and made of plates laid longitudinally, and $\frac{3}{8}$ in. in thickness,

while the safety-valves were loaded to a pressure of a little more than 40 lbs. on the square inch. The boiler gave way, in the first instance, for a length of 5 ft. in a longitudinal direction, at a seam of rivets over the fire, the rent then developing transversely on each side of this primary longitudinal one, stripping from the shell an entire belt of an average width of about 6 ft., and thus separating the boiler into three pieces, one of which, about 21 ft. long, was thrown to a distance of 210 yards from its original seat. The cause of this explosion was not shortness of water. The boiler was twenty-five years old, though it had not worked the whole of that time, being idle from 1844 to 1852. It was fed with sedimentary water drawn from the pit, but had no sludging or blow-out apparatus, either at the bottom of the boiler or the surface of the water, for removing the deposit. The plates over the fire had suffered and been repaired, while the primary rent had occurred in this instance at one of the old plates, and through a seam of rivets uniting it to the new work. There is, therefore, no difficulty in determining the cause of this explosion, and all boilers working under similar conditions are highly dangerous. In putting new plates into these boilers, the work is frequently so strained that they are weakened instead of being strengthened by repairs, and in most cases, at all events, it is impossible to detect this simply by examination, however careful, after the work is completed. This is just one of the reasons that makes this class of boilers so dangerous, and which is illustrated by the fact that the boiler in question is reported to have been examined on the Friday and Saturday before the explosion, when it is to be presumed it was passed as safe, or steam would not have been got up in it. On these grounds it is trusted that it will be seen that the recommendation is not given without good reason, that boilers of this treacherous, plain cylindrical externally-fired construction should be discarded for those fired internally, which are much more reliable.

Steam Boiler Explosions.

From the London Mechanics' Magazine, November, 1865.

Notwithstanding the horrible list of deaths and mutilations from steam boiler explosions which every year, nay, every month, produces, there appears to be little or no increase in care and circumspection in these matters, and, as a consequence, no diminution of catastrophe. If accidents from this cause are not on the increase they certainly are not on the decrease, nor can they be expected to decrease while carelessness, indifference, and parsimony prevail. The two chief evils accompanying the use of boilers are recklessness and incompetency, and these are at the bottom of most accidents. If we take up the monthly reports of the Boiler Insurance Engineers, we rarely find explosions accounted for by any other than circumstances of the most culpable neglect or the grossest ignorance and inefficiency on the part of those in charge. Often, too, does the parsimonious spirit of the proprietor lead to disaster, when he higgles and bargains about a new boiler. He cuts down the price below the figure at which a respectable

house will take the job; he, however, gets it done—by whom and how only occur to him when a coroner's inquest is sitting. But parsimony does not stop at the boiler; the attendant is bargained with and beaten down for a few shillings a week, and sheer ignorance often goes to take charge of an explosive machine which the greatest care and knowledge alone should control. But it is the old story, and some men never seem to know that if they want a good article they must pay a fair price for it, and that a respectable maker's name, whether on a boiler or a coat, is the best guarantee for its wear. Of course, this assumes proper use; a coat will soon be shabby by careless usage, and a boiler will as soon deteriorate if badly tended. Two cases in point occur in Mr. Fletcher's last report to the Committee of the Manchester Boiler Association, one having reference to neglect, the other to incapacity, and both involving parsimony. The first case was the explosion of an ordinary Lancashire mill boiler, having two furnace tubes and being internally fired. Its length was 30 ft. 6 ins., its diameter in the shell 8 ft. 2 ins., and in the furnace tubes 3 ft. 1 in., while the thickness of the plates varied from $\frac{3}{8}$ in. to $\frac{7}{16}$ in. in the shell, and was $\frac{7}{16}$ in. in the furnace tubes. The ordinary working pressure was about 40 lbs. on the square inch, which is not too high for this class of boiler, if well made and well kept.

The boiler was a mere wreck, and the premises were seriously damaged. We need hardly add that there was loss of life and injury. There could be no question as to the cause of the explosion: the flues were not faulty, and there were no signs of overheating of the plates through shortness of water. The explosion simply arose from the rupture of the shell in consequence of the plates being reduced in many places by external corrosion to the thickness of a sheet of paper. The boiler was a cheap one in the first place, and had been at work about eight years; there was constant leakage, constant repairing, and constant administration of a dose of horse-dung. Of course, the story was that this medicine was for the water and not for the boiler—to soften the former, not to stop the leaks in the latter. But considering the condition of the shell, and the general purpose for which horse-dung is put into boilers, it is not hard to assign the true function to the dose which was given after every cleaning. What makes this case worse is the fact that the boiler was well known to be in an unsatisfactory condition, so much so that a boiler-maker had been in negotiation to replace it by a new one last Whitsuntide. But probably the proprietor, mindful only of pelf, could not bring the boiler-maker to his terms, and so resolved to use the old kettle a little longer to balance matters. However this may be, and whatever may have been the qualifications of the attendant, this certainly was a case of the most flagrant neglect, and one which could not have occurred under competent inspection.

The second case occurred with a converted marine boiler, of the steam-tug class of construction. It was a second-hand affair, and had seen some service afloat before it was set to do duty on land. The shell was cylindrical and internally fired, but the flue, instead of go-

ing straight through from the front to the back, as in the ordinary Cornish boiler, returned in a horse-shoe shape to the front end, and passed out through the bottom of the shell into an underneath brick-work flue leading to the chimney. In steam vessels the return flue of these boilers passes out through the top of the shell by means of an uptake, on which the funnel is planted. In adapting this boiler for its new work, however, this uptake had been removed and exchanged for the downtake leading to the brick-work flue above referred to. The boiler was about 13 ft. long, 5 ft. 6 ins. in diameter, and the plates generally about ⅞ in. thick. Here was a boiler badly constructed, badly used, and badly tended, a boy only fourteen years of age having been *appointed engineer* a few hours before the explosion occurred by which he was killed. Comment is surely superfluous here. The poor little fellow, in his ignorant anxiety to get up steam, had only lashed *three bricks* on to the lever of the safety-valve, in addition to the ordinary ball weight! The actual load amounted to 100 lbs. per square inch on the crazy old concern. The pressure does not appear to have reached this point, however, for it is stated that the gauge only registered 50 lbs. a minute or so before the explosion. But the boiler was so badly constructed that even this pressure was quite sufficient to account for the explosion, as may be inferred from the fact that the return flue tube was oval in shape, measuring 2 ft. 6 ins. vertically, and 1 ft. 4 ins. horizontally. This form is weak, and in fact any departure from the cylindrical in furnace and flue tubes materially impairs their strength, if the difference is only 2 ins. In the present instance, the flue departed as much as 14 ins. from the circular shape, and, besides this, was not of a true oval, but was flat or wall-sided for a height of 18 ins. from end to end. The form of the downtake also was weak, one side presenting a flat surface of 2 ft. 6 ins. square, the plate at that part being only $\frac{5}{16}$ in. thick. In short, the boiler was utterly unfit to drive a non-condensing engine at a pressure of 40 lbs. or 50 lbs. per square inch, although it might have jogged on for a time, with a condensing engine, at 20 lbs. pressure. What with the weak construction of the boiler and the way in which the safty valve was overloaded, there is no difficulty in accounting for the explosion.

The question which naturally arises is, How many of these rickety, badly-tended machines are there about us, and where will the next mine be sprung? That there are such there can be no doubt; their whereabouts may only be developed by the coroner's inquest, when it again sits on a few more atoms of parboiled humanity. It is an outrage upon society that men should not only be allowed to place these engines of destruction in our midst, but that they should be under no responsibility as to the tending of them. If no sense of moral obligation exist, it is time for authority to interfere and enforce those conditions which the well-being of the country demands. We cannot conclude without referring to the ignorance manifested by some boiler-makers. This is especially observable in the case of the explosion last alluded to, where the maker, who converted the boiler from a marine to a stationary, could not account for the explosion, neither could a second maker,

by whom it had been repaired, and considered perfectly safe. The hydraulic test—the general adoption of which is so much to be desired—was not applied at the time of the alterations, or the weakness of the flat-sided flue would have been apparent and the explosion averted. But the best constructed boiler could never stand such a reckless overloading of the safety-valve as that above recorded. If owners will not learn the lesson of responsibility of themselves, they will have to be taught it in a way the least palatable to liberty-loving Englishmen.

Description of an Equatorial Clock. By Lord Oxmantown.

Monthly Notices Royal Astronomical Society, May, 1866.

The following description of an apparatus for giving an equable motion to a heavy equatorial of 18 inches apperture may, perhaps, be interesting to some of the Fellows.

It was constructed last autumn, and its merit, if it has any, is that it can be very easily made. No nice workmanship is required; a joiner and plumber can execute the work with sufficient accuracy.

The motive power is a piece of wood, closely fitting a wooden box containing water, on the surface of which this piece of wood floats. This float is covered with canvass, saturated with pitch, to prevent it from imbibing water, and so expanding and sticking fast in the box.

It has, also, pieces of sheet-brass fastened on the edges over the pitched canvass, to prevent the pitch adhering to the sheet-lead with which the box is lined. A tube from the bottom of the box, terminating in a piece of flexible pipe, the extremity of which is kept at a uniform depth below the surface of the water in the box by being suspended from the float, allows the water to escape at a constant rate, which is regulated by a valve in this pipe. *h h* is the box; *i i* the float, which is attached to a brass tube *d d*, which acts as a guide by passing through a hole in the cross-piece of wood *f f*, supported by two upright pieces *g g*; *n n* is the India-rubber tube, through which the water escapes; *o* the valve to regulate the flow; *m* is a cock, which is closed when the clock movement is not required; *q q* a second box to receive the water as it flows out of the first. When we wish to employ the clock, we first pump up water from *q* to *h* through *p* and *l*; secondly, we get the object to be observed into the centre of the field; thirdly, open the cock *m* and clamp the sector *t* to the polar axis *z* by means of the screw *u*; and if the object is not now sufficiently in the centre of the field, it may be brought there accurately by turning the nut *c*, which draws the sector *t* further or near to the float, by bending the spring *w*.

The accuracy of this clock depends, to a great extent, upon the care which is taken to make the sides of the box parallel and flat, so that the horizontal section may be the same at all levels, and to fit the float to it carefully, so that the interval between the float and the sides of the box may be as small as is consistent with absence of friction. Let A be equal to the area in square inches of horizontal surface

of float, and $\frac{A}{n}$ area of interval between the float and sides of the box; then, if the float be displaced $\frac{1}{m}$th of an inch from the position of equilibrium, the surface of the water round the float will be displaced through $\frac{n}{m}$ inches; therefore, if w = weight in lbs. of 1 cubic inch of water, the force tending to bring the float back to its former position $= w \cdot A\left(\frac{n}{m} + \frac{1}{m}\right)$; whereas, if the float had rested on a surface of water of infinite extent, the corresponding force would have been $w \cdot A \times \frac{1}{m}$; $\therefore$ the ratio of the forces in the two cases $= n + 1 : 1$. In the case of the instrument to which this apparatus has been applied, $A = 1296$, and if, for example, the interval between the float and sides of the box $= \frac{1}{18}$ of an inch, and if the variation of friction of the polar axis be taken at 3 lbs., (the average friction being about 7 lbs.,) the displacement of the float, which would have been equal to ·064 of an inch on a surface of water of infinite extent, will become equal to

$$\cdot 064 \times \frac{1}{1 + \frac{36^2}{4 \times 36 \times \frac{1}{18}}} = \frac{\cdot 064}{145} = \cdot 00044 \text{ inches.}$$

As the float is attached to a wire rope, the other extremity of which wraps round the sector t, of 28 inches radius, this deviation corresponds to 7′ 51″ of space in the first case, but only 3′·2 in the second case.

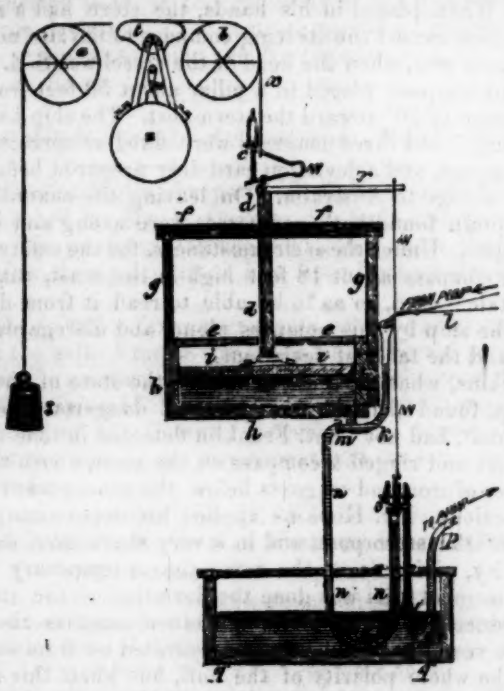
Assuming that the flow of the water from the box will be uniform if the head be unito'm, the only remaining cause of irregularity lies in this, that the overflow is kept at a constant depth below any fixed point in the float, that point, through variation of the resistance, not being at an absolutely invariable distance below the surface of the water in the box; consequently, the head will vary if the immersion of the float varies.

We have seen above that, with a variation of friction of 3 lbs., the variation of immersion = ·064 of an inch; therefore, (47 inches being the distance of overflow below the surface of water,) the ratio of maximum velocity to mean $= \sqrt{\frac{47 \cdot 064}{47}} = \frac{1 \cdot 00067}{1}$, which corresponds to an angular deviation in right ascension of 36″ of space per hour.

In practice, however, when the instrument is accurately counterpoised and carefully oiled, the variation of the force required to turn it round in right ascension is probably very much less than this; and if between one night and the next the friction increases through viscosity of the oil, the rate is easily corrected by means of the valve *o*.

This clock has been used for micrometrical observations, and answers perfectly; but how far for spectroscope purposes it will bear comparison with other contrivances has not yet been ascertained.

The accompanying figure has been drawn on a scale of ½ inch to 1 foot, with the exception of the sector *t* and the weight *s*, which keeps the rope *x* extended, these two parts having been drawn on a reduced scale and in a different position to save space.



Depolarizing Iron Ships.

From Newton's London Journal of Arts, May, 1866.

In the March number of this *Journal* we took occasion to notice an invention which Mr. Evan Hopkins, C.E., had brought before the Royal United Service Institution, in the form of a paper entitled "Iron Ships' Compasses: their deviation and remedies," his object being to call the attention of naval men to a means which he had arrived at, by induction, of depolarizing iron ships, and of giving greater vitality and steadiness to compass needles. We then said we should look with interest to the experiments about to be made to test the practical value of the theory of depolarizing iron ships by passing currents of electricity through the hull. The polarity of iron ships is, as is well known, contracted during building, and the character of the polarity

depends principally on the direction given to the ship's head while building; and it is to the action of this attractive power that the deviations in the compass, which perplex and sometimes baffle the skill of the most experienced navigators, are due. We are now enabled to state that Mr. Hopkins has successfully introduced his new system on board an iron ship called the *St. Leonard*, now loading for Adelaide, in the London docks. This iron vessel is 220 feet long and 34 feet wide. When placed in his hands, the stern had a strong south polarity, which caused the steering compass to deviate nearly 40° toward the stern-post, when the head of the vessel was S.E. by E. Even the standard compass, placed in a pillar about 50 feet from the stern, had a deviation of 20° toward the stern-post. The ship had been carefully "swung," and three magnets were fixed as correctors near the steering compass, and a deviation card duly prepared before she sailed on her last voyage to Australia. On leaving the channel, it appears that the captain found both compasses were wrong and could not be depended upon. Under these circumstances, for the safety of the ship, he rigged a compass about 18 feet high in the mast, with a transparent "tell-tale" card, so as to be able to read it from deck, and he navigated the ship by this compass alone, and disregarded the other compasses and the table of deviations.

Mr. Hopkins, when invited to examine the state of the magnetism of this ship, found that she was in a most dangerous condition, and considered that, had not Capt. Franklin detected in time the errors of the compasses and rigged a compass on the mast, above the influence of the masses of iron and magnets below, the consequence might have been very serious. Mr. Hopkins applied his depolarizing apparatus to the top of the stern-post, and in a very short time destroyed its south polarity, giving it at the same time a temporary weak north pole. The moment this was done the deviation of the steering compass was reduced about 18°, and the other compass about 4°. The plates of the vessel have not yet been operated on from stem to stern to destroy the whole polarity of the hull, but when this is done it is expected that nearly all the deviation will be corrected in compasses placed about 6 feet above deck and 12 feet from the rudder-head and the steering-gear. Mr. Hopkins' standard compass was temporarily rigged up the mast, about 15 feet above deck and 35 feet from the steering-wheel, for the experiment. In this position it was found to be beyond the reach of the disturbing influence of the masses of iron in the ship, and therefore would be found always correct in whatever direction the ship might sail. Besides being a *standard* compass, in which every dependence can be placed, it serves also as a steering compass to the man at the wheel.

The temporary experimental compass, although only about 7 inches diameter, can be plainly read from the wheel, like the dial of a clock, by means of a reflector. Its use, therefore, coupled with the corrections of deviation, will dispense with the swinging business, (which is now acknowledged by careful captains to be delusive and often utterly untrustworthy.) Whatever may be the changes in the magnetism of

the ship in high latitudes, the steersman will have the inestimable advantage of seeing from the wheel at all times a correct standard compass, as well as the one placed on deck near the wheel. This steering standard compass is to have a card of 12 inches diameter, with two needles of the strongest directive power in all "dips" between England an Australia.

We believe that, at the suggestion of Sir John Hay, Mr. Hopkins has been requested to prove the efficiency of his plans for removing the cause of the deviation of the compass needle in iron ships by operating on the armor-plated ship the *Northumberland*.

Property of Sulpho-cyanide of Ammonium. By Mr. F. CLOWES.

From the London Journal of Science, April, 1866.

A notice of an interesting property of sulpho-cyanide of ammonium has been published by Mr. F. Clowes. He finds that when dissolved in water this salt produces intense cold; in a short time the atmospheric moisture being deposited like hoar-frost on the sides of the vessel.

This led him to try a few experiments with weighed quantities of water and of the salt. From a few trials with different proportions, it appeared that the mixture of equal parts by weight gave the most intense cold. By mixing 1368 grains of the salt with its weight of water at 17° C., a cold of 12° C. was obtained. The temperature of the atmosphere at the time of the experiment was the same as that of the water employed.

On National Standards for Gas Measurement and Gas-meters.

By GEORGE GLOVER, Esq.,

Formerly Lecturer on Natural Philosophy, Royal College of Surgeons, Edinburgh, and Vice-President Royal Scottish Society of Arts and Superintending Medical Inspector General Board of Health, Whitehall.

From the London Journal of the Society of Arts, No. 424.

The subject of gas measurement, which I am about to have the honor of bringing under the notice of the Society, involves the consideration of two kinds of instruments—gasometers and gas-meters. The gasometers are of two kinds—the "national standard gas-holders" deposited at the Exchequer, and those in ordinary use, generally called "testing gas-holders." The gas-meters are also of two kinds—the wet and the dry.

When, more than half a century ago, coal-gas came into use, the want of a measure for its sale was soon felt. Such a measure was perceived to be indispensable in the event of gas becoming a staple article of commerce. To meet this want, Mr. Samuel Clegg invented the instrument which, from its revolving drum or measuring part being partially submerged in water, has been denominated "the wet meter." Ingenious in principle, it was soon found defective in practice. Its principal defect arises from the evaporation of the water, causing constant variation in its measuring capacity. The bottom of the measuring

chambers is defined by the plane of water in the meter, and the measuring chambers are diminished or enlarged by the accidental quantity of water which may be present at any given instant. The water is continually undergoing change of level from evaporation, which is more or less rapid according to the quantity of gas which passes through the meter, and the change of temperature. The wet meter likewise varies in its measurement with every departure from the true horizontal plane. Inclined forwards, it measures too slow; if backwards, it measures too fast. It also varies with the varying pressure of the gas as it enters the meter. To render a wet meter a fixed measure four things are essential:

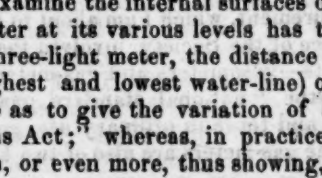
1. That the plane of the water remain fixed.
2. That the bottom of the meter be parallel with the plane of the water.
3. That the meter be placed and maintained on a horizontal plane.
4. That the pressure of the gas as it enters the meter be uniform.

Compliance with these conditions is impracticable, and it is much to be regretted that the baffled ingenuity and futile devices of half a century have not made this conviction general, and that, at the present hour, there should be large towns, such as Liverpool, Birmingham, Sheffield, and several in Scotland, in which gas companies, to their own injury and that of the public, still adhere to the wet meter, notwithstanding its acknowledged defects.

It has been customary, in cases of doubt as to the accuracy of the measurement of gas by wet meters, to lift them from their place, to put them on a horizontal plane, and to adjust the level of the water to a plane of correct measurement. Such a test is no more a proof of a meter's correct performance than a watch-maker's setting a watch to Greenwich time would be an evidence of the watch having gone correctly for the twelve months past, or a guarantee of its accuracy for the twelve months to come. The only correct method of testing the wet meter's performance during any given time it may have been in use, is to examine the internal surfaces of the back and front plates where the water at its various levels has traced or oxidized distinct lines. In a three-light meter, the distance between the two extremes (viz: the highest and lowest water-line) ought not to exceed $\frac{3}{16}$ths of an inch, so as to give the variation of 5 per cent. allowed by the "Sales of Gas Act;" whereas, in practice, that distance is found to reach an inch, or even more, thus showing, of course, a proportionate amount of variation in the measuring capacity of the meter. The diagrams (Fig. 1) will illustrate this.

Fig. 1.

Diagrams of wet meters, showing the precise amount of variation.



Two-light Meter.—Scale 1 inch = 1 foot.

Registering 88 per cent. against consumer.
" 7 " " company.

	Square Inches.
Area of segment down to correct water-level, 16·94 + 8·46 =	25·40
" " " " highest "	16·94
Against consumer—variation	8·46
Then as 25·40 : 8·46 :: 100 : 33·3 per cent.	
Area of segment down to lowest water-level	27·22
" " " correct "	25·40
Against company—variation	1·82
Then as 25·40 : 1·82 :: 100 : 7·16 per cent.	

Five-light Meter.—Scale 1 inch = 1 foot.

Registering 9 per cent. against consumer.
" 29 " " company.

Area of segment down to correct water-level	= 45·31
" " " highest "	41·81
Against consumer—variation	3·5
Then as 45·31 : 3 5 :: 100 : 8 96 per cent.	
Area of segment down to lowest water-level	58·71
" " " correct "	45·31
	13·4
Then as 45·31 : 13·4 :: 100 : 29·49 per cent.	

There has been no lack of effort to remove this defect in the wet meter. Ingenuity, labor, and vast sums of money have been lavished upon it. The Patent Office, year after year, has been besieged by inventors who imagined they had discovered a remedy; but, for all practical purposes, there has been little, if any, improvement on the original invention.

The inventions which have aimed at preserving a fixed water-line may be reduced to three classes: Those having a reservoir or small cistern in connexion with the meter, and a tube communicating with the surface of the water in the meter, on the principle of a bird fountain; those in which a spoon or bent tube on the axle lifts a small quantity of water in each revolution by dipping into a cistern or water-box; those which float the drum itself, or have a float nicely balanced, of semi-cylindrical or hemispherical form, turning on a horizontal axle mounted near the level of the water in the meter. Many of those inventions have, from time to time, obtained partial success. Some of them have been revived again and again under different names and with slight modifications, but all of them have ended in failure and disappointment. The method of floating the drum Mr. Clegg invented

shortly before his death. The simplicity and theoretical beauty of the invention are apparent, and, could the sides of the revolving drum be kept vertical to the plane of water, the drum itself perfectly balanced and free from deposit; could the water be kept pure, the pressure of the gas free from variation, the moving parts from corrosion, it might be hoped that one serious practical objection to the wet meter had been removed. These conditions, however, all experience has shown cannot be realized.

Vigorous efforts are being made to revive the use of a meter, constructed on the same principle of floatation, which was patented by Messrs. Sanders & Donovan in 1855. Theirs is the simplest and most scientific invention yet propounded for preserving the uniform level in the water-line. Its ingenuity reflects high credit on the inventors. But, without unfairly detracting from this, it may be stated that their invention has increased both the size and complexity of the instrument, that its extreme delicacy and the complication of its parts, while multiplying the chances of error in its workmanship, expose it to quicker decay, and hence repair and replacement are necessarily more frequent. Its delicacy, in fact, unfits it for every-day use, and makes it very liable to derangement. The water in the meter becomes impure and even tarry, impurities, from time to time, are deposited on the float, its balance is impaired, its axle and the float corrode, small holes are formed in it by corrosion, through which the water enters, when it ceases to be a float, so that it not only fails to adjust the level of the water, but becomes more defective than the ordinary wet meter.

It is open, besides, to the very serious objection that, by unscrewing the lower plug, as much gas can be got as from the outlet of the meter itself, a circumstance which offers a strong temptation to fraud.

The variation in measurement is, of course, the grand objection to the wet meter. It is not the only one, however. Though fatal in itself, there are others I may just mention. There is the annoyance from the unsteadiness of the lights, familiarly called "jumping." There is the danger of sudden extinction. There is the danger of escapes of gas through the meter being interfered with, as when the plugs are removed that the water may be replenished, and, through carelessness, not replaced. There is the facility with which the measurement in the same wet meter can be made to vary, either from the quantity of water put into the meter, the inclination given to it, or from both, and the consequent temptation to fraud. There is the necessity of placing it in the basement of the house, and the consequent attempt to prevent the "jumping" of the lights by giving all the pipes a gradual rise from the meter to admit of the water trickling back into it, an attempt at once futile, expensive, and injurious to house property. Its very situation in obscure, out-of-the-way corners is apt to create a suspicion in the mind of the consumer that he is wronged in his measurement, while the gas companies are made dependent on the vigilance of their inspectors to an extent undesirable alike for the employer and the employed. The defects of the wet meter too often

expose the managers and directors of gas companies to unjust suspicions, while really the companies are the greatest losers by it, and the parties most deeply interested in the just measurement of gas. When the meter is found not to have registered at all, or to have registered only a small portion of the gas passed through it, it is not unusual to ask the consumer to pay for his gas without any reference to the meter, but to his payment for the corresponding quarter of the previous year, a mode of adjustment unsatisfactory both to the seller and the buyer.

The interests of the public and the gas companies alike demanded that the evils of a system of measurement, which involved variations reaching sometimes as high as 20 and 30 per cent., should be fairly met. "Why," it was asked, "should not gas be justly measured as other staple commodities are measured? Why should not the consumer have a guarantee that he really gets the quantity he pays for, and the producer that he really gets payment for the quantity he delivers? If security be given for the just measurement of a gallon of oil and a pound of candles, it is not less necessary for a cubic foot of gas." From evidence given before Parliamentary Committees, it appeared that, owing to the want of a legal criterion and inspection, what was called a cubic foot differed, when measured by the meters of one manufacturer as compared with those of another, as much as 8 per cent., and that when the meters were in the most perfect working condition. The prevailing dissatisfaction, and the antagonism, prejudicial alike to the gas companies and the public, to which this state of things gave rise, at length drew the attention of the Legislature to the subject. The result was the bill presented by Lord Redesdale to the House of Lords, in the first session of 1859, for the purpose of establishing a standard cubic foot for gas measurement, and extending the general law of inspection of weights and measures to gas meters, with such other provisions as the special nature of the subject seemed to require.

The "Sales of Gas Act," introduced by his Lordship, received the sanction of the Legislature in the session of 1859. The principal provisions of that Act are sufficiently well known. It fixed, for the first time, as the "only legal standard or unit of measure for the sale of gas by meter, the cubic foot, containing 62·321 pounds avoirdupois weight of distilled or rain-water weighed in air at the temperature of 62° of Fahrenheit's thermometer, the barometer being at 30 inches." And had the Act done no more than this it had conferred an important boon on the gas companies, and on the community at large. A first and important step was then taken in the right direction.

The duty of providing standard measures for gas was devolved by the Act on the Lords Commissioners of Her Majesty's Treasury. The Astronomer Royal's familiarity with the subjects of the standards of weights and measures specially qualified him for such a duty, and his services to the Exchequer in connection with this subject having been acknowledged as of high value, their Lordships applied to him to assist them in providing the requisite instruments. The public and the

gas companies were entitled to expect that the services of a philosopher so distinguished in the application of the exact sciences, should be made available to attain, in the standard measure for gas, as much accuracy as possible.

Acting under the authority of the Lords Commissioners, and aided by Professor Miller, of Cambridge, the Astronomer Royal provided a bottle for measuring the cubic foot defined in section ii. of the Act. In his report to their Lordships of the 11th of February, 1860, he says, "Acting under the authority given by your letters of October 14 and 15, 1859, and having secured the valuable assistance of Professor W. H. Miller, I caused to be prepared a weight of 62·321 lbs., constructed of hard gun-metal, and a metallic vessel or bottle, intended to contain 1 cubic foot, constructed of thin copper, in shape a cylinder with a cone at each end, the upper cone having a small cylindrical neck for the introduction of water, and the lower one having a tap for its discharge." Whether the bottle so described was the best instrument for the purpose may, I think, be fairly questioned. Made of copper it was liable to corrode. The thin sheet of copper was liable to change of form when filled with water, as well as from external injury. Once filled it could not be readily dried. I submit that a geometrical solid, made of anti-corrosive metal, made to exclude, not to contain, the water, and losing in weight the precise quantity of distilled water defined in clause ii., would be free from the objections stated, and could be easily dried after each experiment. It could be preserved, if laid on a soft cushion, under a glass, at the Exchequer, for any length of time, without change or diminution.

Having obtained a bottle fitted to contain the "unit of measure" required by section ii. of the Act, the Astronomer Royal's next step was to apply it in accordance with section iii., which requires that, "within three months next after the passing of the Act, models of gas-holders, measuring the said cubic foot, and such multiples and decimal parts of the said cubic foot as the Lord High Treasurer or the Commissioners of Her Majesty's Treasury shall judge expedient, shall be carefully made, with proper balances, indices, and apparatus for testing the measurement and registration of meters, and such models shall be verified under the direction of the Lord High Treasurer or the said Commissioners, and, when so made and verified, shall be deposited in the office of the Comptroller-General of the Exchequer at Westminster."

In carrying this enactment into effect, it was found that none of the gas-holders hitherto in use for testing meters could be adopted as a standard measure. The more prominent objections to them were these:

1. Their measuring part was not truly cylindrical.

2. No two gas-holders agreed in measurement. Not only did they differ from each other to the extent of 3 or 4 per cent. in their measuring capacity, but the various divisions into feet, and the sub-divisions of the feet, differed in the same gas-holder.

3. The material of which they were made was very liable to corro-

sion when in contact with gas and water. To retard this corrosion paint was used. The paint in the inner surface of the bell diminishes its measuring capacity, and its renewal from time to time aggravates the evil. The coating of paint softens, swells, frequently rises in blisters, falls off in flakes, or crumbles away. In its ascent from the cistern, the painted surface of the bell brings with it a quantity of water, which adheres to it in the form of a film, and numerous drops, which adhere especially to the inner surface of the flat cover. These occasion further diminution of capacity, whilst the evaporation of the water on the outer surface of the bell lowers the temperature, diminishes the volume of the gas contained, and causes error in the testing of meters.

4. The scales of the existing gas-holders were found liable to corrosion, and, not being attached to the bell, they could be readily tampered with. These reasons were sufficient to preclude their adoption as standard measures.

The construction of such instruments as the Act required becoming daily more pressing, and urgent representations being made to the Treasury on the subject, I submitted my designs to the Astronomer Royal, and I had the honor to be employed by the Lords of the Treasury to superintend the construction of the "national standard gas-holders, with proper balances, indices, and apparatus for testing the measurement and registration of meters."

The idea of a legal standard measure, I need scarcely say, involves the highest attainable accuracy. Neither the Legislature nor the public would be satisfied with anything short of this. The subject of weights and measures, even for solids and liquids, for length and capacity, is one of much practical difficulty. The records of the Royal Society abundantly testify how much time, labor, and thought have been given to the solution of these apparently simple questions, "What is a pound weight?" "What is a yard?" Not to travel back into the remote past, I need only remind you of what happened when the Houses of Parliament were destroyed by fire in 1835, and the yard measure perished with them. A Royal Commission was appointed to restore it. After deliberating some twelve years they could find nothing fixed, either in time or space, to which to appeal for a standard measure. Neither the seconds pendulum nor the arc of the meridian of the French philosophers could be appealed to, and they had no alternative but arbitrarily to decide that the rod they had deposited at the Exchequer was a yard. But in constructing a standard measure for gas, the difficulties are much more complicated. The body to be measured is an aëriform body, invisible, highly elastic, varying in volume with every barometric change, very complex in its chemical constitution, affected by every change of temperature, liable to condensation and to be absorbed by water, of which it is also an absorbent.

(To be continued.)

Japanese Matches. By R. Trevor Clarke.

From the London Chemical News, No. 267.

The curious little Japanese fire-work, or one closely allied to it, has been long known to me. I saw it, when a boy, exhibited by an Italian juggler under the name of "garofanetti," or "pinks," alluding to the starry flower-like coruscations produced by it. The sorcerer was, of course, reticent as to the formula, but I set to work and finally succeeded in finding it out. It is a form of the beautiful and very curious spur-fire of the Chinese,—so curious as to be worth scientific investigation.

I enclose specimens, and here follows formula: Lamp-black 5, sulphur 11, gunpowder from 26 to 30 parts, this last proportion variable with the quality of the powder. Grind very fine, and make the material into a paste with alcohol. Form it into dice, with a knife or spatula, about a quarter of an inch square. Let them dry rather gradually, as on a warm mantel-piece, not too near a fire. When dry, fix one of the little squares in a small cleft made at the end of a lavender stalk, or, what is better, the solid, straw-like material of which house-maids' carpet brooms are made, (panicular stems of *Arundo donax.*) Light the material at a candle, hold the stem downwards, and await the result. After the first blazing off a ball of molten lava will form, from which the curious coruscations will soon appear.

For the Journal of the Franklin Institute.

The Working Processes for the Reduction of the Gray Copper (Tetrahedrite) Ores at Stefanshütte, in the Comitat (County) of Zips, in Hungary. By J. L. Kleinschmidt.

The proper working of the gray copper ores is one of the most difficult metallurgical processes. At the Stefanshütte it is now done on a larger scale than any where else in the world. These works, which received a prize medal at the London Exhibition of 1862, were established 16 years ago, and produce, at present, about 300 tons of copper, 3000 lbs. of silver, 60,000 lbs. of quicksilver, and 80,000 lbs. of crude metallic antimony. The works built for the smelting of the gray copper, use of yellow ores only poor quartzose ones, which are necessary for fluxing. The processes, therefore, have a character quite different from that in other places, where the gray copper ores form only a small part of the materials to be melted. One of the main progresses in the last years is the production of metallic antimony from gray copper ores, since more than one-half of the regulus antimonii, which comes in the market from Hungary, is now produced from these ores.

The pure gray copper ores contain, according to the analyses of Von Hauer, (Jahrbuch der Geolog. Reichsanstalt, 1852. Heft 4, page 102:)

	I.	II.	III.	IV.	V.	Name of the mine.
S	25·90	13·38	24·87	24·89	22·00	I. Bind Appolonia.
Cu.....	36·59	34·23	30·58	32·80	39 04	II. Andraei.
Fe.....	7·11	9·46	1·46	5·85	7·58	III. Gustav Frederici.
Hg	3·07	3·57	16·69	5·57	0·52	IV. Heilg. Geist. Tr.
Sb	26 70	33 33	25·48	30·18	31·56	V. Rothbaum.
As.....	trace.	trace.	trace.	trace.	trace.	
	99·37	99·97	98·58	99·29	100·50	
Spec. G.	4·605	4·762	5·107	4·783	4·582	

The above ores contain from $\frac{1}{2}$ to 3 ounces of silver in 100 lbs., the average yield of the ores being $\frac{1}{2}$ of an ounce. Besides these, ores are furnished to the smelting works, which contain *no* quicksilver; the ores are therefore separated into two classes—in those containing quicksilver and in those free from it. The veinstone of the mercurial ores consists almost exclusively of carbonate of iron. The other minerals, which are associated and intermixed, sometimes do not amount to 1 per cent. of the sparry iron. The average yield of copper is 10 per cent. Besides gray copper ores, the ores contain about 3 per cent. of yellow copper ores; so that they consist of gray copper ores 2 per cent., yellow copper ores 3 per cent., carbonate of iron 69·3 per cent., other minerals, as heavy spar, slate, quartz, and calcareous spar 0·7 per cent. The ores therefore contain about 7 per cent. of sulphur and 8 per cent. of antimony. The annual production is about 2500 tons of ores, containing about 400,000 lbs. of antimony.

Separation and Collection of the Mercury.—The great volatility of this metal requires that it should be separated first. The process is a very simple one, but nowhere else in use, and consists in the roasting of the ores in large round furnaces, and collecting the quicksilver in the upper layer of the ore. On the bottom of the furnace is placed a layer of fine ore of 4 inches in thickness, then follows a layer of wood of 22 inches, and on this 6 inches of charcoal. Now follow layers of partly roasted ore, but not yet free of quicksilver. The fine ore is added in stripes radiating from the centre, whilst between these the lumps are placed, otherwise the furnace would have no draft. Therefore the ores, which have been once roasted, but yet contain mercury, are separated by sieves into fine ore and lumps. Uppermost come the fresh unroasted ores, and the top layer, in which the quicksilver is condensed, consists in lumps only of different sizes, (Stufen & Graupen.) The whole quantity amounts to 50 tons, and forms a layer about 2 feet high. A wood-pile is in the centre of the kiln, from which it is fired and burns during about four weeks. In consequence of the heat produced by the burning of the ores, the mercury is volatilized, and passes through the upper layers of the ore, where it is condensed in the form of globules. It is only necessary that these remain throughout and at all times cold, and that the places which perhaps get warm

are at once covered with cold lumps to prevent the loss of mercury; therefore watchmen are at the furnaces, day and night, during the whole process of operation.

After the kiln is burnt out, the upper layer, which is full of metallic quicksilver, is cautiously taken away, and washed in wooden tanks by the help of sieves, as it is done in the washing of ores. The quicksilver goes through the sieve, and remains with the ore dust on the bottom of the tank. From the latter it is separated by boys, who wash it in small wooden troughs. For this purpose in a building are three tubs containing water, and on each of them stand three or four boys, ten to sixteen years old. Every one takes some of the mixture of dust and quicksilver in his trough, (sichertrog,) and, keeping it below water edge, he gives it a great many small shocks against the wall of the tub, whereby the quicksilver settles to the bottom of the trough. The water of the tub is mixed with some quicklime, otherwise the quicksilver would contain copper. That part of the roasted ore which yet contains quicksilver is worked over a second time, as described above; the lower portion, however, which is free of mercury, goes to the furnace. The quicksilver obtained is not pure; it contains silver and copper, and must be distilled in an iron retort. The distillation must be conducted very slowly, otherwise traces of copper are also volatilized. If carefully done the distilled mercury contains no foreign substances, except some sub-oxide of mercury. Formerly, when the distillation was done too rapidly, the quicksilver sometimes contained traces of copper. The residuum in the retort consist in ore dust and metallic silver, the latter containing copper and gold.

After the roasting, almost the entire lower part is melted together, and most of the sulphur has combined with the iron of the sparry iron. The volatile products formed by the roasting have a strong smell of sulphurous acid and bisulphuret of carbon. Besides the smoke of wood, there are generally no other vapors emanating from the roasting kiln. Sometimes arsenious vapors can be perceived. In this roasting process there are never observed the dense vapors, which arise by the roasting of the matte, (lech,) but the atmosphere contains only an invisible gas, which acts seriously on the eyes and lungs.

The yield of the ore by this process is 94 per cent. of the mercury, found by assay. In former times a great many and costly experiments were made to distill the quicksilver in retorts, furnaces, and every possible apparatus, and to condense it then in chambers and pipes placed in cold water; but the above simple method, by which fresh cold ore is employed for the condensation of the quicksilver, has superseded all others.

In relation to the chemical process, the protoxide of iron of the sparry iron may have a prominent part in driving out the mercury, because the melted mass on the bottom of the furnace consists partly of sulphuretted metals and partly of antimonial metals, (speiss.) Most of gray copper ores give out metallic mercury by heating them in a sealed glass pipe; in others, here and there red cinnabar can be seen. The latter yield the mercury only by heating them in an open pipe,

so that we have three causes here, by which the quicksilver is set free: 1. The heat alone; 2. The oxygen of the air; and 3. The influence of the oxide of iron. The average yield of the ores amounts to 1·63 per cent. of mercury.

Matte Smelting, (Rohschmelzen.)—After the separation of the mercury the ore is smelted. The mixture consists of roasted ores with about 40 per cent. of the crude gray copper ores, free of mercury, and to 100 of this mixture are added 6 parts of iron pyrites of Schmöllnitz, 20 parts of poor quartzose ores, and 20 parts of slag of the melting of the roasted matte, (lech.)

Qualities and Composition of the Materials.—It was above mentioned that the lower part of the roasted heap, which is free of quicksilver, consists of sulphurets and antimoniurets of metals. Above it is a layer, also free of quicksilver, consisting chiefly of peroxide of iron, and very little protoxide. The carbonate of iron is in this layer very rare, as it has mostly been changed into peroxide.

The composition of the raw ores can be stated as follows: Gray copper ores 26 per cent., yellow copper ores 4 per cent., sparry iron 64 per cent., slate and quartz 4 per cent., and arsenical iron 2 per cent., and about 2 ounces of silver in 100 lbs., which is more than the average yield of the mercurial gray copper ores.

Pyrites of Schmöllnitz.—These are bought from several companies, which work, besides the Austrian government, on the well-known deposits of pyrites called the Kiesstock. These pyrites ores give, by the crucible assay, 70 per cent. of matte, (lech,) contain ½ of an ounce of silver in 100 lbs., and less than ½ per cent. of copper, ½ to 4 per cent. of lead, and small quantities of zinc, antimony, and arsenic.

Quartzy Flux Ores.—These are yellow copper pyrites ores dispersed in quartz. The average yield of these ores is from 3 to 6 lbs. of copper in 100 lbs. They contain only small quantities of iron pyrites, arsenical iron, sparry iron and gray copper ores. These ores are received at the melting works about one-third in lumps of about an inch in diameter, and two-thirds as ore dust, (scheidklein.)

The furnaces employed for the melting are so-called half-high furnaces, of the following dimensions in Austrian measure: From bottom stone to the mouth 24½ feet, from bottom stone to the tuyeres 6 feet, from the tuyeres to the cinder hole, downwards, measured 29 inches, height of the boshes 1½ feet, inclination of the boshes 45°, width of the bottom of the hearth 8½ feet, width of the boshes 5 feet, of the mouth 18 inches. The furnaces are circular, and the 2 tuyeres blow in the centre of it. They have a diameter of 1¼ inch on the mouth. The pressure of the air is seven-twelfths to ten-twelfths inch quicksilver. The rough mason-work of the furnaces is of slate—the interior shaft of fire-proof talcose slate. They stand on a foundation 15 feet high, which lays on solid rock. The melting is done by a half-lighted nose, and one furnace melts in 24 hours 5 tons of ore.

The cinders or slags are tapped every 15 minutes, and the tapping hole is stopped with loam. There are prepared several small but deep crucibles (tiegel) in front of the furnace, united by a kennel. The

last consists in a flat hollow of 7 to 8 feet in diameter, which is called *sump*, (sumpf.) In the first of the crucibles, whilst the melted metals take their way through them, the "speiss" is deposited, covered by a layer of matte, (lech,) but the most of the latter goes to the sump, in which it hardens to a layer of one to two inches in thickness, and while yet warm is broken to pieces. As soon as the tapped metals are cold, the smelter takes away the solid matte by a fork, (forkel,) and when he comes to the speiss he puts in it a piece of iron, which has a ring above, by the means of which he takes it out after cooling.

I have found the composition of the products of the matte melting (rohschmelzen) to be—

Matte, (produced Feb., 1864.)	
Cu	22·10
S	25·80
Fe	47·62
Sb	3·37
Ag	0·08
Slag	1·40
	100·37

Speiss, (produced June, 1864.)	
Cu	26·93
Sb	62·41
Fe	8·91
Co. & Ni	0·20
S	1·37
Ag	0·20
	100·02

Slag, (rohschlacke,) (produced Feb., 1864.)

SiO_2	46·60
S	2·24
Sb	0·80
Cu	0·40
FeO	42·21
CaO	3·78
MnO	2·60
Al_2O_3	0·80
	99·43

Conditions for the Formation of the Speiss.—The formation of the speiss was known to me already in 1847, when I became acquainted with it at the imperial Altwasserhütte, where, at that time, the same gray copper ores were worked up, which are now used at the Stefanshütte. In 1853 I was engaged on the melting works of Wissenbach, near Dillenburg, in the Duchy of Nassau, Germany, in finding a method for the profitable working of the gray copper ores of that district. The veinstone of these ores, renowned for the beauty of the crystals and the scarcity of their occurrence, consists of quartz. I added slag from puddling furnaces, slag from the melting of roasted copper matte, and some lime, but no speiss was obtained. I soon found that the production of speiss depended upon the presence of metallic iron in the melting process. I obtained speiss without difficulty by the direct addition of wash iron, (from the stamping of slag of an iron furnace,) as also by that of roasted sparry iron. The matte melting (rohschmelzen) of the Stefanshütte does, therefore, not produce any secretions of metallic iron, (eisensauen, salamander,) as it is the case at the Phönixhütte and other melting establishments, belonging to the same association, and where the yellow copper ores are melted, because, instead of the iron, and by the aid of it, the easily fusible antimony is separated.

So long as it was not possible to extract the silver from the speiss by amalgamation, its appearance was not liked. The desideratum was to make as small a quantity as possible, and several times experiments were made to avoid its production altogether. Only recently a method was discovered to separate, by amalgamation, the silver from the speiss with the same facility and quite as perfectly, as from the black coppers. Besides this, a method was found to reduce the yield of copper in the speiss to such an extent that the copper in the crude antimony is more than paid, so that it is now perfectly reasonable to reduce more and more the addition of the pyrites, which prevented the formation of too large a quantity of speiss, and to produce more speiss, and to work it up by itself. Not taking into consideration the considerable quantity of antimony, which thereby is gained, the main profit is in the diminution of the by-products; further on we will see that the working up of these forms a great part of the operations of the Stefanshütte, and that it is certainly easier to separate the antimony at once than to volatilize it by an endless series of processes. The second reason is that thereby a much better copper can be produced. It will be seen from the analyses below, that cobalt and nickel go chiefly into the speiss. These elements, in combination with the antimony, impart bad qualities to the copper, but it is much more convenient, therefore, to separate them from the copper by precipitating them in combination with the antimony, than by driving them into the slags in the refining process of the copper.

The speiss of this melting has a gray color, almost that of steel, the fracture is fine-grained, sometimes with traces of crystallization. It is very brittle, and can easily be converted to the finest powder; red-hot in contact with the air it gives white fumes. The specific gravity differs but little from that of the matte, therefore and because the mass runs with great rapidity through the crucibles, the speiss has no time to separate perfectly. The same contains, therefore, some matte mixed with it, which is visible in small particles. From it comes the sulphur, which is shown by the analysis. On the other hand, the matte contains visible particles of speiss. From the above analysis it will be seen, and the results on a large scale prove it, that the speiss contains three times as much silver as the matte, produced at the same time. Formerly, before it was understood, how to amalgamate the speiss, the loss of silver was very great; now, the antimony has proved itself a conservator of the silver, the latter not being more subjected to the losses, which are inevitable by the roasting of the matte, for the purpose of melting them to black copper. Besides that, the silver is gained three months sooner than when obtained from the black copper.

First or Crude Matte, (Rohlech.)—Bredberg determined the amount of sulphur in the matte (rohlechs) to 26 per cent., which accords with the above. (The same is the case with the matte of the Phönixhütte.) Results quite different from these are given by Le Play in his examinations of the Swansea melting processes. The amount of copper, too, is far less than in the matte of the English melting works. In Hun-

gary they fear to lose copper, if the first matte contains more than 25 per cent. of this metal. The matte of the Stefanshütte forms a mass, with a great many blisters, of steel-gray to violet color; because it gets solid in the sump. In a pretty thin layer it is easily broken to pieces. I made a great many trials to ascertain the amount of antimony in the matte. By the roasting of these mattes an immense quantity of white smoke emanates from the heaps, which is so dense that it is impossible to see through it. In the night this smoke is seen from a distance of some miles as a fiery cloud. By seeing this great quantity of smoke, and considering that the produced black copper contains yet 8 to 13 per cent. of antimony, the quantity of 3·58 per cent. of antimony seems too small; but notwithstanding there are not less than 126,000 lbs. of antimony in the 3,500,000 lbs. of matte, produced during a year. Of these are found 34,000 lbs. in the black copper, (400,000 lbs. with 8·5 per cent. Sb,) so that 92,000 lbs. of antimony pass into the air by the roasting of the matte and the melting for black copper. The 400,000 lbs. of antimony contained in the ores, which are smelted during a year, are distributed as follows:

	Pounds.		Pounds.
Lost by the first melting.....	60,000	Annual production of—	
Contained in the crude speiss...	190,000	Speiss.....	300,000
" " " slag....	24,000	Slag.....	3,000,000
" " " matte..	126,000	Matte.....	3,500,000
	400,000		

Crude Slag (slag) from the Melting for Matte, (Rohschlacke.)—The crude slag of the Stefanshütte was in former times of a pale, stony aspect, contained visible quartz pieces and interspersed grains of matte. It was very imperfectly decomposed by chlorhydric acid. Since the addition of the pyrites was diminished, the visible quartz pieces have mostly disappeared, the color of the slag became darker, and interspersed grains of matte are very rarely visible. The amount of SiO_3 in well melted pieces is fallen from 50 per cent. to 46·60 per cent.; yet this is more than that of the crude slag of the Phönixhütte, where the majority of the ores are quartzose.

This result is astonishing. The ores of the Stefanshütte contain only oxides as veinstone, and the quartzy ores are only added to remove these oxides in the form of slags. Now, where the acidity of the slags is known, the tendency is to diminish the quartzy additions, otherwise the diminution of the pyrites from 14 per cent. to 6 per cent. has rendered the slags more fusible, because a larger quantity of sparry iron can thereby be turned into slags. The same process could be observed here as by the formation of the Skumnas at Atvidaberg, in Sweden; in both cases, by the great amount of sulphur in the mixture, the slag was deprived of iron.

The melters, therefore, add much more kupferrostschlacke, (slag, obtained by melting roasted matte for the argentiferous black copper,) if they can get it, than the above-mentioned 20 per cent. They further add limestone to increase the fusibility of the slag, wherefrom the

presence of lime, shown by the analysis. The slag of the Stefanshütte could previously never be used for making slag bricks, which were needed in great quantities for building purposes and paving, and were brought from the Phönixhütte; but now, since slags are produced containing less silica, and are therefore more easily fusible, and less stony, they can be used for slag bricks. The small amount of antimony in the crude slag is very remarkable, whilst it rises in the slag of the refining process to 20 per cent. By the crude melting a great portion of the antimony is volatilized, partly from the mouth, partly from the so-called "lichtloch," (lighthole,) an aperture of about one inch diameter opposite the tuyeres, from where it bursts out with white flame, which at night is employed for lighting the works. According to my calculations, by the first melting about 60,000 lbs. of antimony escape to the atmosphere.

Methods of Analysis.—The analysis of all these antimonial products has great difficulties, because the decomposition by chlorine or the melting with sulphide of potassium were not practicable for most of these products, containing small quantities of antimony, and which are often difficult to reduce to powder. I adhered to the method of dissolving them in fuming nitric acid; but hereby very often basic salts are formed, which cannot be decomposed by nitric acid, and which, when once dry, are insoluble in hydrochloric acid. Reischauer, in Munich, analyzed such a substance remaining from the solution of copper, used by the coppersmiths of Munich, but does not mention the melting works, where the copper was produced. (Die Parasiten des Werk-kupfers, Oestr. Zeitschrift, f. Berg. and Hüttenw., 7 Nov., 1864.) He found in it, after being dried over oil of vitriol,—

SbO_5	66·61
PbO	10·91
CuO	7·97
SbO	2·28
NiO	2·17
FeO	1·66
HO	8·22
	99·82

I have not always obtained basic salts; from crude speiss and speiss resulting from the melting of refining slag always, but never from crude metallic antimony free of iron, (see below.) In general it seems they are formed when the solution goes on slowly, and if the substance, to be dissolved, is in excess of the solvent. This residue, after slight glowing, I calculated as SbO_4, but I always examined it before the blow-pipe, and then made the necessary deductions. For that purpose I weighed a part of it, mixed it with cyanide of potassium, soda, and some borax-glass, and melted it, enveloped in a cylinder of soda-paper, before the blow-pipe, whereby iron, cobalt, and nickel could easily be recognised. It is possible, when cobalt and nickel are present in small quantities only, to estimate their quantity according to the intensity the borax beads obtained. The copper remains as a

pure grain, and can be weighed exactly. Here the figures obtained by the analysis of the crude speiss, (rohspeise.)

One gramme reduced to fine powder was dissolved in pure fuming nitric acid. The solution was diluted, and after the residue was perfectly settled, filtered, and then washed, ignited, and weighed = 0·790 gramme = 63·667 per cent. of antimony. 0·0200 gramme of this residue gave 0·0025 grammes of copper = 0·987 per cent. This deducted from above remain 62·68 per cent. of antimony; of iron only a trace was present; of nickel a trace; cobalt could not be found in it, but in several samples of the speiss its presence was indicated to the extent of about 0·2 per cent., by borax beads before the blow-pipe.

(To be continued.)

On Scientific Experiments in Balloons. By JAMES GLAISHER, F.R.S.

Proceedings of the Royal Institution of Great Britain, No. 41.

(Concluded from page 51.)

The speaker stated that, at the end of the year 1863, the results for temperature were laid down on a diagram, and the resulting curve was a hyperbola. Continuing this curve upwards, and reading out the decrease of elevation, the following were the results: That at the height of

50,000	feet		the decline of temperature from the earth would be			83	degrees.
100,000	"	or 19 miles		"	"	97	"
200,000	"	38 "		"	"	106	"
538,000	"	100 "		"	"	112½	"
1,056,000	"	200 "		"	"	115½	"

Showing that large changes take place near the earth, amounting to 24° in the first mile, becoming less and less the further removed, till the change from 100 miles to 200 miles is less than 3°.

The speaker then said, as these results were deduced chiefly from experiments in the summer and during the hours of the day, it became desirable to take experiments at other times in the year, to ascertain whether this law would hold at all times of the year and at all times of the day.

For this purpose it was necessary to take experiments in the winter, spring, and autumn. He then described the experiments made at these seasons, and pointed out that experiments made on September 29, January 12, and April 6, during the day, differed very much from the general laws, and those on June 18, 20, and 27, made a little before, at the time of sunset, and a little afterwards, differed materially from those made when the sun was at a good altitude; for instance, on June 18, at the time of sunset, no difference in temperature was experienced for 2000 feet from the earth.

The speaker then said, it is very clear from the particulars of each ascent, that they cannot all be combined or all used in deducing general laws. Those ascents which have been made during the past year under similar circumstances to those from which the laws of decrease of tem-

perature were found, when combined, do not change the values previously found to any great amount; but those which have been made under other circumstances, such as in the winter, and at times of the setting sun, differ very greatly indeed.

The deviation from this law, however, in winter is certainly of the highest importance to us, the meeting of a strong current of air from the south-west of so great a depth as nearly one mile, over our country on January 12, in the season of winter, which current I know continued many days, must have exercised great influence. This was the first instance of meeting with a stream of air of higher temperature than on the earth; above this the air was dry, and higher still it was very dry: fine granular snow was falling thickly above this warm stream of air.

The south-west current being thus observed is of the highest importance as bearing upon the very high mean temperature we experience during winter, so much higher than is due to our position on the earth's surface, and it is highly probable that to its fluctuations the variations of our winters are due.

Our high winter temperature has hitherto been referred for the most part to the influence of the heated water of the Gulf Stream, but if this were the case, the same agency being at work around the coast of France should exercise the same influence, yet we know that the winters of France are more severe than our own, though situated so much south of us.

Dr. Stark of Edinburgh, some years since, referred the mildness of the winters in Britain for the most part to prevalence of the south-west or anti-trade wind, which is the prevailing aërial current in this latitude during winter.

He observes, so long as these winds blow, we have no frosts or intense colds; but the moment the wind changes during winter to an easterly, north-easterly, or northerly direction, we have both frost and snow, and more or less intense cold.

The south-west winds, in their course, meet with no obstruction in coming to us, but they blow directly to us and to Norway over the Atlantic; and hence we enjoy a much milder climate during winter than any other lands not similarly situated with regard to such winds.

The south-west winds cannot reach France until they have crossed the whole of Spain and the high mountain range of the Pyrenees; and by the time they have crossed that mountainous country they are so much cooled that France can derive comparatively little benefit from them, and hence, apparently, her more severe winters.

Another fact may be inferred from this winter trip; it has always been a matter of great difficulty to me to account for the simultaneous appearance of dense fog over the whole country and extending far out to sea, but the fact of a warm current of air, situated under a mass of snow falling, would fully account for the production of any amount of fog.

Another inference may be drawn from the facts noticed. One only I will mention, and it is this: If during the prevalence of a warm

current of air passing over these islands there can be currents of air of so low a temperature as I experienced, it is evident that, as it is but a struggle between two or more forces, either of which may preponderate at any moment, it is not safe, therefore, in the winter months, how mild soever the weather may be, to go thinly clothed at any time, for at any moment this warm current may be deflected, and its place occupied by the old current, and thus some of our sudden and apparently unaccountable changes may be due.

The fact of no change of temperature being met with at the time of sunset on June 18, for 2000 feet from the earth, that a much smaller change took place than usual on June 20, a little before sunset; and that on June 27, after sunset, as well as could be determined, the change to 3000 feet was small, it would seem that the *laws which hold good by day do not hold good by night. Indeed, it seems probable that at night, for some little distance, the temperature may increase with elevation instead of decreasing.* This can only be determined by experiments at night.

Comparing the results of one experiment with another, with respect to the moisture in the air, at the same elevation, it is found to be very different at different times, and that, on the same day, the moisture is very differently distributed, there having been on some of the days of experiments several successive wet and dry strata placed one above the other.

The variation in this climate, its frequent disturbed atmosphere, the smallness of the country, causing great anxiety after passing through clouds and out of sight of the earth, for fear of descending over the sea, when the balloon has no longer power to keep up, rendering each experiment so limited in its duration, that perhaps this country is not the best for determining the laws which govern atmospheric changes.

I am glad to learn that similar observations are contemplated being made in France, and I hope that similar observations will be made in other countries, for it is probable that above the large plains of the continent, where the weather is more uniform, and where an observer can be for hours out of sight of land without anxiety—that the experiments can be more easily made, and probably, too, the general laws made more easily apparent.

Many ascents will, however, be necessary; clouds as large, and clouds far colder than any I have met with, were experienced by Messrs. Bixio and Barral, in their ascents in June and July, 1850, from Paris. These gentlemen made two ascents for scientific purposes, and although from accidents the ascents were of short duration, the results were of high interest. Among them, they noticed that they passed through a cloud of icicles, which sustained themselves in the air, as it appeared to them, contrary to the laws of gravity; but upon their horizontal surfaces they saw beneath them, however, an exact image of the sun, formed by the reflexion of the luminous ray on the crystals of ice floating about in a foggy atmosphere; and they noticed the temperature of the cloud to be as low as minus 40°, a far greater degree of cold than I ever experienced.

With such variations as these, as many ascents will be necessary to be made in France as in England, to determine general laws; but each ascent may be made far richer in results than any one in England. In France, the duration of a journey will be limited only by the wishes of the observer and not as here by the sea, or by one solitary hour's observations—that being the time frequently in which we approach the sea.

It is certain that there are, in the higher regions of the earth's atmosphere, spaces subjected to great cold, and others to considerable heat; that there exist some clouds of very low temperature; and some, as those passed through on January 12, for a mile in thickness, of comparatively high temperature.

The presence of such, either cold or hot, currents passing over the country, must play an important part in all our meteorological phenomena, and must exert a great influence upon our climate.

When I first undertook to make these experiments, I expected that a few ascents would have given the information sought. The number of experiments I have now made is twenty-five, and so far from exhausting the subject, they have only indicated a much wider field for future operations.

The law of decrease of temperature under ordinary circumstances, both with a clear and a cloudy sky, when the sun is above the horizon, in the months of summer, I think, is pretty well determined; but from the series of observations made in winter, we cannot say such laws hold good throughout the year: neither can we say that the laws which hold good by day will be true by night; and the general result of these differences must be that the theoretical law of refraction now used must be abandoned, and that every observatory will have to determine its own laws independently.

Solar Radiation.—Blackened Bulb Thermometer and Herschel's Actinometer Observations.—On August 31, at the heights of 7000 and 8000 feet, the blackened bulb thermometer, exposed to the full influence of the sun, read 3° only higher than the shaded thermometer.

On September 29, at the height of 14,000 feet, the excess of reading of the blackened bulb thermometer was 2¼° only under a bright sun, the increase of readings of the actinometer was from 3 to 5 divisions only; at 13,000 feet, the excess of the blackened bulb readings increased to 4° and 5°, and the increase in one minute of the actinometer reading were 7 to 8 divisions. At the height of 3000 feet and 4000 feet, the influence of the sun increased, raising the blackened bulb to 7° and 8° in excess of the readings of the shaded thermometer, the scale readings of the actinometer increased to 20 and 25 divisions in one minute, and on reaching the ground the increase in the same time were from 45 to 50 divisions.

On January 12, the readings of the exposed and shaded thermometers were nearly alike.

On April 6, I was unable to use the actinometer, and never succeeded in placing it properly. The excess of reading of the blackened bulb thermometer was but small during the cloudy state of the sky

and increased to 5° and 6° at 10,000 feet; this excess increased on descending into the lower atmosphere, until cloud was entered.

On June 18, the excess was at all times small.

On June 20, at many inspections, the readings of the two thermometers were identical.

On June 27, the exposed thermometers nearly always read lower than the shaded thermometer; on examination of these instruments afterwards, they were both found to read correctly.

On August 29, the blackened bulb thermometer read lower than the shaded thermometer till 6000 feet were passed; it then read higher, increasing to 7° at 14,000 feet high.

From all these experiments it seems that the heat rays in their passage from the sun pass the small bulb of a thermometer, communicating very little or no heat to it, similar results being shown by the use of Herschel's actinometer on every occasion that I have had an opportunity of using it. *From these experiments we may infer that the heat rays from the sun pass through space without loss, and become effective in proportion to the density of the atmosphere or the amount of water present through which they pass, and if so, the proportion of heat received at Mercury, Venus, Jupiter, and Saturn may be the same as that received at the earth, if the constituents of their atmospheres be the same as that of the earth, and greater if the density be greater, so that the effective solar heat at Jupiter and Saturn may be greater than at either the inferior planets, Mercury or Venus, notwithstanding their far greater distances from the sun.*

Different Velocities of Air.—The Wind.—On September 29, the balloon left Wolverhampton at 7 h. 43 m., A. M., and fell near Sleaford, a place ninety-five miles from the place of ascent, at 10 h. 30 m., A. M. During this time the horizontal movement of air was thirty-three miles, as registered at Wrottesley Observatory.

On October 9, the balloon left the Crystal Palace at 4 h. 49 m., P. M., and descended at Pirton Grange, a place thirty-five miles from the place of ascent, at 6 h. 30 m., P. M. Robinson's anemometer, during this time, registered eight miles at the Royal Observatory, Greenwich, as the horizontal movement of the air.

On January 12, the balloon left the Royal Arsenal, Woolwich, at 2 h. 8 m., P. M., and descended at Lakenheath, a place seventy miles from the place of ascent, at 4 h. 10 m., P.M., at the Royal Observatory; by Robinson's anemometer, during this time, the motion of the air was six miles only.

On April 6, the balloon left the Royal Arsenal, Woolwich, at 4 h. 8 m., P. M. Its correct path is not known, as it entered several different currents of air, the earth being invisible owing to the mist. It descended at Seven Oaks, in Kent, at 5 h. 37 m., P. M., a point fifteen miles from the place of ascent; five miles was registered during this time by Robinson's anemometer at the Royal Observatory, Greenwich.

From all the experiments, *the velocity of the air at the earth's surface appears to be very much less than at a high elevation.*

Different Currents in the Atmosphere.—The Wind.

1862.—July 30.

The direction of the wind before starting was N. W.

At 4h. 41m. 15s.,	at	480	feet,	the direction of the wind was	S.W.
" 5h. 17m. 30s.,	"	5165	"	" "	N.N.W.
" 5h. 40m. 30s.,	"	6183	"	" "	N.

1862.—September 1.

The direction of the wind before starting was E.N.E. verging to E.

At 5h. 4m. 0s., P. M.,	at	3208	feet,	the direction of the wind	E.N.E.
" 5h. 10m. 0s.,	"	3318	"	" "	E.
" 5h. 11m. 30s.,	"	3560	"	" "	E.S.E.
" 5h. 17m. 0s.,	"	3580	"	" "	E.N.E.
" 5h. 36m. 0s.,	"	4190	"	" "	W.

1863.—March 31.

At 4h. 58m. 0s., P. M.,	at	18,302	feet,	the direction of the wind was	N.E.
" 4h. 58m. 30s.,	"	17,097	"	" "	S.W.
" 5h. 12m. 0s.,	"	20,865	"	" "	nearly W.
" 6h. 15m. 0s.,	"	4,441	"	" "	S.E.
" 6h. 16m. 0s.,	"	5,168 moving back again.			

1863.—July 11.

Before starting the wind was E.

At 4h. 59m. 30s.,	at	2633	feet,	the direction of the wind	N.
" 7h. 14m. 0s.,	"	1876	"	"	E.
" 7h. 56m. 45s.,	"	1020	"	"	S.E.
" 7h. 57m. 0s.,	"	1000	"	"	W.

1864.—January 12.

At 2h. 9m. 0s.,	at	655	feet,	direction of the wind was	N.E.
" 2h. 14m. 0s.,	"	1,328	"	"	E.
" 2h. 11m. 0s.,	"	1,518	"	"	S.W.
" 2h. 32m. 0s.,	"	5,401	"	"	S.
" 3h. 3m. 0s.,	"	8,086	"	"	S.S.W.
" 3h. 20m. 0s.,	"	10,017	"	"	S.S.E.

Comparison of the Temperature of the Dew-point by different Instruments.—In the experiments of every year, there seems to be no certain difference in the determination of the temperature of the dew-point by Daniell's and Regnault's hygrometers, and this temperature, determined by the use of the dry and wet bulb thermometers, seems to be very closely approximate indeed to the results obtained by either of these instruments, as will be seen by the following comparison of results.

As found from all the simultaneous determinations of the temperature of the dew-point by Daniell's hygrometer, and the dry and wet bulb thermometers (free), the temperature of the dew-point by the dry and wet bulb (free) up

Feet.	Feet.	Deg.	Experiments.
	to 1,000	was 0·1 lower than by Daniell's hygrometer from	21
From 1,000	" 2,000	" 0·1 " " "	40
" 2,000	" 3,000	" the same as by " "	54
" 3,000	" 4,000	" " " "	60
" 4,000	" 5,000	" 0·4 lower than by " "	33
" 5,000	" 6,000	" 0·6 " " "	33
" 6,000	" 7,000	" 0·2 " " "	34
" 7,000	" 8,000	" the same as by " "	8
" 8,000	" 9,000	" 1·5 higher than by " "	2
" 9,000	" 10,000	" 1·2 " " "	2
" 10,000	" 11,000	" 0·3 " " "	1

From 11,000 to 12,000	was	5·6	lower than by	Daniell's hygrometer	from 3
" 12,000 " 13,000	"	0·3	higher than by	"	" 5
" 13,000 " 14,000	"	0·8	lower than by	"	" 7
" 14,000 " 15,000	"	1·0	"	"	" 2

The number of experiments made up to the height of 7000 feet, varying from 21 to 60 in each 1000 feet, as taken in the last three years, are sufficient to enable us to speak with confidence; the results are, that the temperatures of the dew-point, as found by the use of the dry and wet bulb thermometers, and my hygrometrical tables, are worthy of full confidence up to this point. At heights exceeding 7000 feet, the three years' experiences do not yield a sufficient number of experiments to give satisfactory results. Before we can speak with certainty at these elevations more experiments must be made.

Let us take the balloon as we find it, and apply it to the uses of vertical ascent; let us make it subservient to the purposes of war, an instrument of legitimate strategy, or employ it to ascend to the verge of our lower atmosphere; and, as it is, the balloon will claim its place among the most important of human inventions, even if it remain an isolated power, and should never become engrafted as the ruling principle of the mechanism we have yet to seek.

Whether we regard the atmosphere as the great laboratory of changes which contain the germ of future discoveries, as they unfold to the chemist, the meteorologist, the physician; its physical relation to animal life at different heights; the form of death, which at certain elevations is certain to take place; the effect of diminished pressure upon individuals similarly placed; the comparison of mountain ascents with the experiences of aëronauts; these are some of the inquiries which suggest themselves, and faintly indicate researches which naturally ally themselves to the course of balloon experiments.

Sufficiently varied and important they will be seen to rank the balloon as a valuable aid to the uses of philosophy, and rescue it from the impending degradation as a toy, fit only to be exhibited or to administer to the pleasures of the curious.

Already it has done for us that which no other power has accomplished; it has gratified the desire natural to man, to view the earth in a new aspect, and to sustain himself in a new element, hitherto the exclusive privilege of birds and insects. We have been enabled by its aid to ascend among the phenomena of the heavens, and to exchange conjecture for instrumental facts, recorded at twice the elevation the highest mountain permits us to observe.

A New Star.

Dr. B. A. Gould, Jr., of Boston, publishes in the *Boston Transcript* an account of the discovery of a new variable star in the constellation of the Northern Crown. The star, when first seen, on the night of the 14th of May, was brighter than any other, except one, of that constellation, which would put it between the second and third magnitudes.

It now appears that it was observed on the night of the 12th of May, by a pupil of the Friend's High School, in this city, and on the same night by Prof. Tutweiler of Havana, Green Co., Alabama, who reports it as "about or above the second magnitude, and a little brighter than Alphecca or Gemma, (α Coronæ.) It rapidly decreased, on the 19th was barely visible to the naked eye, and on the 20th was visible only through a small telescope, and it continued to decrease at an almost uniform rate until the 24th of May. The Paris journals notify us that the same star was detected by M. Courbebaisse, at Rochefort, on the night of the 13th of May. Its position and brightness accord with the observations here.

The close accordance of the times of detection of this star will show how closely the heavens are now watched, and how familiar even amateurs are with the principal stars of the heavens.

Since the above was written we learn from the Monthly Notices of the Royal Astronomical Society, (England,) that this same star was noticed on the night of the 12th by Mr. Birmingham, of Tuam, who has, therefore, decided priority of discovery. But a more important fact is that Mr. B. immediately reported his discovery to Mr. Higgins who has recently given us, by means of the spectroscope, such valuable information in reference to the physical constitution of the stars. His results are so interesting that we give his report in full.

"On May 16 I received a note from Mr. John Birmingham, of Tuam, in which he informs me that, on the night of May 12, he saw a new star near ε *Coronæ* B. He describes the star as 'very brilliant, of about the second magnitude.' The same day a letter arrived from Mr. Baxendell; he observed the star on the 15th, and found it to be fully equal in brightness to β *Serpentis* or γ *Herculis*.

"On the night of the 16th, I and Dr. W. A. Miller examined the spectrum of this strange star. The results of our observation were communicated on the 17th to the Royal Society.

"On the 16th, the star was brighter than ε *Coronæ* B, fully ·5 magnitude, perhaps ·75 magnitude brighter than ε. On that evening a very faint nebulosity was seen extending some little distance round the star, and gradually fading away at its outer boundary. A comparative examination of neighboring stars showed that this appearance of nebulosity was due to the star itself. On the evenings of the 17th, 18th, 19th, and 21st no certain indications of a nebulous light about the star could be detected.

"The spectrum of this star is very remarkable, and leads to unexpected conclusions as to its physical condition.

"The light of the star is compound, and has emanated from two different sources. Each light forms its own spectrum. The principal spectrum is analogous to that of the sun. The portion of the star's light represented by this spectrum was emitted by an incandescent solid or liquid photosphere, and suffered partial absorption by passing through an atmosphere of vapors existing at a temperature lower than that of the photosphere.

"This absorption spectrum contains two strong lines, a little more

refrangible than C of the solar spectrum; a shaded group of lines extending nearly to D; a faint line coincident with D; numerous fine lines up to about the position of *b* of the solar spectrum, where a series of groups of strong lines commences and extends as far as the spectrum can be traced.

"The second spectrum, which in the instrument appears to be superposed upon the one already described, consists of five *bright lines*. This order of spectrum shows that the light by which it was formed was emitted by matter in the state of *gas*.

"One of these bright lines is in the red at the position of Fraunhofer's C. The brightest of the lines coincides with F; a little beyond this is a fainter line; near this line a fourth occurs, which is either double or undefined at the edges. In the more refrangible part of the spectrum, probably not far from G, a fifth bright line was seen by glimpses.

"On the 17th I observed this spectrum of the star simultaneously with the bright lines of hydrogen produced by the induction spark. The brightest line coincided with the centre of the expanded green line of hydrogen. Apparently the red line also coincided with that of hydrogen, but the faintness of the star spectrum did not permit the coincidence to be observed with certainty.

"These bright lines are all much more brilliant than the corresponding refrangibilities of the continuous spectrum over which they fall. We must, therefore, conclude that the temperature of the gas by which the light, consisting of these five refrangibilities only, was emitted, must be much higher than that of the stellar photosphere from which the principal part of the star's light has emanated.

"On the 17th, 19th, and 21st, the spectrum of the star was again examined. No important changes had occurred. In the faint spectrum of the fading star, on the 21st, both spectra could be seen. Some additional groups of absorption lines are probably present in the continuous spectrum, but the gaseous spectrum is not changed otherwise than in the diminution of its brilliancy. The sudden blazing forth of this star, and then the rapid fading away of its light, suggest the rather bold speculation that, in consequence of some great internal convulsion, a large volume of hydrogen and other gases were evolved from it. The hydrogen, by its combination with some other element (the other bright lines do not coincide with those of oxygen) giving out the light represented by the bright lines, and at the same time heating to the point of vivid incandescence the solid matter of the photosphere.

"The grouping of the dark lines of the absorption spectrum is similar to that which characterizes the spectra of *α Orionis* and *β Pegasi*, stars in the atmosphere of which *no hydrogen exists*.

"We have found that several of the more remarkable of the variable stars which have an orange tint have spectra similar to those of *α Orionis*. It is worthy of notice that all the white and bluish-white stars have spectra in which, on the other hand, the dark lines due to absorption by hydrogen are very strong, whilst all the other lines are

thin and faint. These, and other observations we have made, suggest that hydrogen probably plays an important part in the changes and physical differences of constitution of the stars.

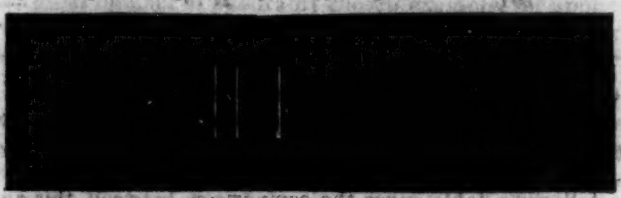
"The grouping of the lines of absorption of this new star shows that its color would be orange, if it were not for the greenish-blue light of the bright lines, which more than makes up for the refrangibilities which have been intercepted by absorbent vapors. Mr. Hinds writes: 'On the 19th, the star was perfectly white and stellar to my eye.' Mr. Baxendell's remarkable powers of observation enabled him to divine some of the results of prismatic examination which at that time were not known to him. He writes: 'On the 18th I several times received the impression of a bluish tinge, as if the *yellow of the star were seen through an overlying film of a blue tint.*'

"On the 17th, the star's exact position was obtained at Greenwich. The Astronomer Royal informs me that a meridian observation showed that this strange object 'agrees precisely with Argelander No. 2765 of 'Bonner Sternverzeichniss,' declination + 26°, magnitude 9·5.' Mr. Baxendell writes to me: 'It is propable that this star will turn out to be a variable of long irregular period, and it may conveniently be at once designated T *Coronæ*.' Mr. Baxendell gives, in his letter, the following table of the magnitudes of this wonderful star:

"'A reduction of all my observations gives the following results:

1866.	h.	m.		Mag.
May 15 at	12	0	G. M. T.	T Coronæ = 3·6 or 3·7
16 "	10	30	"	" = 4·2
17 "	11	0	"	" = 4·9
18 "	12	30	"	" = 5·3
19 "	12	15	"	" = 5·7
20 "	12	30	"	" = 6·2'"

Diagram of the Spectrum of Absorption and the Spectrum of Bright Lines forming the Compound Spectrum of the temporarily Bright Star near ε Coronæ Borealis.



MISCELLANIES.

Improvement of the Teasel.—It would seem that no artificial apparatus has ever been found to replace entirely this plant (*Dipsacus Fullonum*) in dressing cloth. M. Gohin proposes, therefore, to prepare the natural head by the same process of mineralization as is used for the preservation of wood. Experience has shown that the heads they prepared lose none of their natural elasticity or delicacy, that they last much longer, and work as well when wet as when dry. The Society for the Encouragement of National Industry at Paris confirms the good report of this application.

Gelatine from Marine Plants.—M. Natalis Rondot made to the same Society a very interesting communication on the subject of the marine plants from which the Chinese procure gelatine, either as an article of food or for use in the arts. The subject would seem to deserve attention from us, both as a means of reducing the price of a valuable article of diet, and as a means of introducing cheaper substitutes for materials of which the large consumption in the arts is raising the price seriously. The same families of plants inhabit our coast, and doubtless gelatine as delicate in flavor, and as strong, could be easily and cheaply prepared from them.

Thermo-electric Piles.—The *Cosmos* gives an interesting account of a paper upon this subject, from which we extract the following tables. In a former article attention was called to the discovery, by M. Becquerel, of the remarkable energy of a pile composed of sulphide of copper and German silver. The following table gives an idea of its power as compared with a Daniell couple, the electro-motive force of the Daniell being reckoned 100.

Difference of temperature of ends.	Electro-motive force.	
	Maximum.	Mean.
100° Cent.	3·40	1·50
200	5·98	3·17
300	8 70	6·08
400	12·63	11·15
460	17·82	16·75
500	21 75	.....
800	88·06	.....

In order to produce the maximum effect, the sulphide of copper must be annealed by exposure for several hours to a low, red heat. If, however, the heat be brought up to the point of fusion, (1040° Cent.,) the thermo-electric power is entirely destroyed.

The following table gives the comparison between this and other thermo-electric couples, the difference of temperature in the ends of the couples being, in each case, 100° Cent., and the force of Daniell being, as before, considered 100°.

+	−	
Tellurium.....	German silver.....	4·121
Sulphide of copper.....	" " (max.).....	3·402
Alloy of 806 antimony, 696 cadmium	Alloy 10 Bismuth, 1 antimony.....	2·761
" 806 " 406 zinc.....	German silver.....	1 426
Antimony.....	Bismuth.....	0·532

From which it appears that the new pile, when carefully made, is more than six times more powerful than the one in ordinary use.

Disease of Oysters.—It appears that the oysters of Norway have been subject to an epidemic, which the Institute of Christiana calls "a pestilential consumption," and the result of which is to render the flesh of the oyster a virulent poison, of which many persons have died. Let us hope that their oysters caught cold from being exposed too long to draughts of air, and that, at all events, the disease will not, like the pork trichinæ, extend to other countries.

BIBLIOGRAPHICAL NOTICES.

The Differential Calculus; with unusual and particular analysis of its elementary principles, and copious illustrations of its practical application. By JOHN SPARE, A.M., M.D. Boston: Bradley, Dayton & Co., 1865. 12 mo., pages 244.

Mr. Spare claims for his book that it is the first of any character which has been written and published in America on the calculus, as the special topic of a volume. In this he is evidently mistaken, as the work of Prof. Church, and those of many others, might have shown him. We have carefully examined it, in consequence of the claims to high and exclusive merit which are put forth in the preface, but confess to our inability to find much foundation for such pretensions. It is a well digested and well written work upon the calculus, presenting the subject clearly and comprehensively, but the only great superiority which it shows over other treatises on the same subject, in our opinion, is the great number of admirably chosen examples for application. In this very important respect we are inclined to give it preference to any treatise which we have seen in the English language. F.

Lippincott's Vapor Index.—Mr. Jas. S. Lippincott of Haddonfield, N. J., whose earnest and persevering labors in meteorological science are so well known and appreciated among us, has just sent us a movable table, by which the humidity of the air is at once read off from the indications of the wet and dry bulb hygrometer. The temperatures of the wet bulb are arranged on a fixed rim surrounding a movable disk, upon which are printed in spiral form the differences of the temperatures of the wet and dry bulb. On bringing any given difference to correspond with a temperature in the margin, the relative humidity expressed in hundredths of saturation appear through holes pierced through the disk, and corresponding to the differences of temperature. The arrangement is ingenious and simple, and makes a very elegant and useful piece of apparatus for the meterological student, to all whom we warmly recommend it as saving much time in looking up tables, or in calculation.